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ART. I.—*Comparison of Experiments on American and Foreign Building Stones to determine their relative strength and durability;* by Prof. WALTER R. JOHNSON, of Washington, D. C.

As we have in the United States but few ancient buildings, the age of which can furnish conclusive proofs of the durability of their materials, and as but few of the materials which are found in such abundance and variety in this country, have been subjected to any satisfactory experimental tests to prove either their strength or durability, it is desirable that a rigorous comparison should be made, not only between the results of such trials on American rocks as have been made, but also between them, and such foreign materials as have been tested by the most careful experimenters, and have besides undergone the more decisive proofs of many centuries of use in public edifices and monuments. As nature has in many situations exposed these various materials to the direct action of all the causes which can work their gradual destruction, and as these destructive causes have evidently wrought with an efficacy on some rocks vastly greater than on others, it is clear that if we would ascend to the highest and most reliable proofs of durability, we must seek for them in the condition which the rocks themselves have been able to maintain, not for the few brief centuries to which the memory of man extends, but during the geological ages which run back immeasurably beyond all human history. Those rocks which amidst the denuding, disintegrating and decomposing influences, whether derived from sweeping currents of water, from meteoric actions and changes of temperature, or from vegetable growth

and decay, have been able to sustain themselves in high, bold, naked, angular cliffs, unprotected by soil, and yet unfurrowed by irregular disintegration, are manifestly those to which the engineer and architect are to direct their attention, when they seek materials for durable works of art. On the other hand, they will shun those rocks which the causes above enumerated have kept constantly down to a level with the ground, or which barely rise in some few patches to the surface, and are there seen disintegrating, scaling away, and covering themselves with a soil derived from their own debris.

The chemistry of geology furnishes to the architect and engineer most important hints for guiding their selection of materials; hints which when taken with other tests and proofs, leave them without excuse for choosing those of an inferior character. The influence of such a substance as iron pyrites on the durability of rocks in which it occurs, is so well known to every one acquainted with even the rudiments of geology and mineralogical chemistry, as scarcely to need a formal statement.* The effect of carbonic acid with water in dissolving carbonate of lime, and the readiness with which it acts on loosely aggregated crystalline masses of that carbonate, to effect their disintegration, may be understood from any elementary work on chemistry. The greater solubility of sulphate than of carbonate of lime may be ascertained from the same source. The weakness of coarsely crystallized stones as compared with those of finer texture, is so well known as to be properly classed among the canons of architecture.†

Of all the purposes for which building materials are employed, that which requires the utmost attention to durability is the erection of national monuments. It is a mockery to the dead, and an opprobrium to the living to put perishable materials into structures professing to perpetuate the virtue of great and good men. The Spanish nation is represented to have recently determined on the erection of a magnificent statue of bronze to rest on a base of rose granite, the most enduring of that species of rock, to commemorate the glory of Columbus.

The question of the strength of a material to resist a crushing force is sometimes a vital one, as has been painfully proved within a year or two past in some of our large cities, where extensive warehouses have been crushed beneath their own weight and that of the goods which they contained, occasioning fearful losses of life. But the crushing test has by no means a single aim. It looks to the relation between the cohesion of a material and its capacity to resist the action of other than mechanical causes of

* "Pyrites when present (in granite) renders the rock unfit for use, as it decomposes and stains or rusts the surface, besides loosening the grains and causing the rock to fall to pieces."—*Dana's Mineralogy*, p. 579.

† Borgni's "Constructions Diverses," p. 23, and Rondelet's "Art de Batir."

disintegration. It is certainly a most egregious mistake to construct any tall public edifice in such a manner as not to sustain its own dead weight, but there are operations scarcely less discreditable, and which apply with equal force to structures professing to be enduring whatever be their height, their form, proportions or weight.

The usual trial of materials in small cubes is intended to furnish the relative strength or durability of the several species of materials to which it is applied.

The stone used in the Washington National Monument, and referred to in the following comparisons of experiments, is the same as that mentioned under the name of "*alum limestone*," in the report of the building committee to the Regents of the Smithsonian Institution, Dec. 7, 1847.

"The marble quarries of Maryland, chiefly in the vicinity of the village of Clarksville, about thirteen miles from Baltimore, on the line of the Susquehanna Railroad, contain two qualities of marble; one fine grained and of beautiful uniform color, approaching the character of statuary marble; the other of inferior quality, similar to the Sing Sing marble employed in New York in Grace Church and other public structures, of a somewhat coarse and highly crystalline structure, and known to the quarrymen here under the name of 'alum limestone.'"*

Trials of these two kinds of stone by the the process of Brard† were made by Dr. Page in 1847, and shewed that "an inch cube of the fine-grained marble lost in four weeks about one-fifth of a grain; and a cube of the best quality of the 'alum stone,' or coarse-grained marble *from half a grain to a grain and a half.*"‡

This indicated with sufficient clearness the inferior durability of the coarse-grained stone; since it underwent from *two and a half* to *seven and a half* times as much disintegration as the fine-grained variety. The fine-grained stone is understood to be derived from the Taylor quarries, half a mile westward of Cockeysville, and about a mile distant from the Griscom lime quarries which are at a place called Texas, where the "alum limestone" used at the National Monument is procured. At the latter quarries the stone is worked wholly below the original surface of the ground. At a few points along the outcropping edge of the bed, the harder parts of the rock come to the surface of the ground or rise occasionally one or two feet above it, covered in places with loose granules of the same rock. In some parts it is eroded into sloping channels, lined with skeletons of crystals and their slightly cohering nuclei.

On removing the soil, the rock is found with alternating peaks and cavities; its surfaces are more or less deeply tinged with the

* Hints on Public Architecture, by R. D. Owen, p. 114.
† Ann. de Chim. et de Phys., tom. 38. ‡ Owen, p. 116.

oxyd of iron derived from decomposed iron pyrites, many veins of which traverse it in various directions, and the skeleton crystals with loosely cohering nuclei are even more conspicuous than at the points where the rock crops out as above described.

That even the fine-grained stone above mentioned is not in all respects suitable to be employed as the casing stone of large shafts, is proved by the present condition of the shaft of the Washington Monument in Baltimore, where a similar stone from the same neighborhood was used. This monument was commenced on the 4th of July, 1815, and the statue was elevated on the 19th of October, 1829. On the 23d of October, 1850, or twenty-one years from the date of its completion, I examined from the platform at the base of the shaft the condition of its lower part.

There was seen on the side of the shaft opposite to the northeast corner of the base, a crack commencing near the bottom and following partly the joints of the masonry, and partly certain transverse or vertical cracks crossing the blocks of marble. The 3d, 5th, 8th, 10th, 11th, 13th, 14th, and 15th courses of stone, counting from the bottom, were seen to be broken either partly or wholly across, and in one instance a block is broken into three pieces. On the southeasterly side of the shaft is a second line of fracture crossing ten or twelve blocks, mostly alternating with the courses of masonry which have joints corresponding with the general course of the fissure. At the southwesterly side are fifteen blocks cracked either partly or wholly across, and forming a third fissure more or less in a zigzag direction, controlled apparently in some degree by the joints of the masonry. On the west side a fourth line of fracture appears to ascend some forty or fifty feet, and on the northwest side still a fifth line perhaps somewhat more irregular in direction than the preceding, but still easily traceable by the eye. In some cases where the cracks on two alternate blocks meet the joint of masonry in the course between them, the opening of that joint is apparent; in other words the crack is here in the cement, as might reasonably be expected. How long these cracks have existed, I have no means of ascertaining. But one thing seems certain, that alternate cold and heat, rain and frost, will, along these lines of fissure, produce their usual effects of thrusting farther and farther apart the masses which bound them. Time will reveal the effects, and perhaps expose the causes of these incipient dilapidations.

A chemical analysis of the "alum limestone" has been published by Dr. L. D. Gale, which makes the composition of that sample to be

Carbonate of lime, ...	98·6
Silica or other insoluble matter, . .	1·4
	100·

I have also found one very white specimen in which the insoluble matter was only 0·4 per cent., but even from the solution of this, ammonia threw down a slight brownish precipitate of oxyd of iron.

A specimen of the blue vein variety showed the following characters:—Its specific gravity was 2·708. 1218·4 grains pulverized and carefully washed, afforded a residue of 5·5 grains of iron pyrites (and an inappreciable quantity of adhering silica,) equal to 0·45 per cent. 100 grains treated with strong acetic acid, lost 73·7 per cent. Strong boiling nitric acid applied to the insoluble residue dissolved the pyrites, and the sulphuric acid thence produced was precipitated with chlorid of barium, giving 1·62 grains, equivalent to 0·42 grains of iron pyrites, agreeing very nearly with the mechanical analysis.

The acetate was dried up, converted into carbonate and then redissolved and precipitated with oxalate of ammonia, to separate the lime, after which ammonio-phosphate of soda threw down of phosphate of magnesia 1·3 grains, equivalent to 0·47 grain of magnesia, or to 0·97 grains of carbonate of magnesia. From this it should seem that the sample was composed of

Carbonate of lime, ...	72·73
Carbonate of magnesia, . . .	0·97
Sulphuret of iron, ...	0·42
Insoluble silicates, ...	25·88
	100·

As the pyrites is one of the chief coloring matters of the dark veins, it is evidently very variably distributed through the stone. The crystals of sulphuret are mostly small, but easily detected, by the naked eye.

On breaking a weathered portion of the pyritous vein it is often found penetrated from one to two or three inches by the coloring matter (peroxyd of iron). On the interior parts of the discolored portion, the pyrites will be found but partially decomposed. On the outer portions it will have wholly given place to the peroxyd. On the fresh surfaces not reached by rust, the yellow pyrites remains unchanged.

When an attempt is made to polish a surface of the alum limestone, portions will occasionally be detected which from their softness render fruitless all attempts to impart lustre to them. On careful examination they will be found so soft as to be readily scratched with the finger nail. In many parts, little triangular cavities, from which it appears the last remnants of the solid angles of crystals have dropped out in the operations of cutting and polishing, will be easily discovered by the eye, and slight lines forming the boundaries of the large crystals are not unfrequently traceable when the piece is brought into a strong light. A block thus polished will have all its crystals of pyrites from their su-

perior hardness left slightly elevated above the surface of the carbonate of lime which is worn away in polishing.

The surface of polished stone thus variously marked with elevations and cavities, may be used like an engraver's plate, and will give an impression of its own markings, of much interest.

1. *Trials of two-inch cubes of the coarse-grained "alum limestone," used at the National Washington Monument, to ascertain its resistance to crushing. By Dr. Charles G. Page.*— The specimens were stated to have been furnished by the owner of the quarries, and the testing to have been performed by the aid of a "powerful hydraulic press," so arranged as to "indicate accurately the amount of pressure." Not having witnessed any of the experiments or the arrangements of the machine, the writer feels bound to say that these allegations respecting the machine have been published by the architect, by the superintendent, and by others concerned in building the monument at Washington. These experiments were communicated to the writer by Dr. Page.

No. of the trial.	Crushing weight in pounds per square inch.
1.	910
2.	1372
3.	2281
4.	2312
5.	2437
6.	2531
7.	2625
8.	2650
9.	2750
10.	2843
11.	2968
Average strength,	2334

Note.—From the above it appears that the greatest strength per square inch, when tested in two inch cubes is 2968 pounds, and the least 910 pounds, the latter being about 30 per cent. of the former number.

2. *Trials by Dr. Page, of other building materials* to obtain results, on two-inch cubes, comparable with those afforded by the "alum limestone."

No. of trial.	Kind of stone.	Crushing weight in lbs. per square inch.
1.	Fine-grained marble of Symington,	4562
2.	Another sample of do.	4400
3.	White veined marble, East Chester, N. Y., used at the General Post Office,	4081
4.	do. another specimen,	3906
5.	Italian marble,	3156

No. of trial.	Kind of stone.	Crushing weight in lbs. per. square inch.
6.	Patapsco granite,	2941
7.	do. another specimen,	2593
8.	Seneca sandstone, (Smithsonian building,)	2691
9.	do. do. another specimen,	2691
10.	Stockbridge marble, Mass.,	2410
[11.	*Alum limestone*, (*casing of monument*,) average as above,	2334]
12.	Stockbridge marble, 2d specimen,	2093
13.	York road freestone, (a friable brown sandstone,)	2125
14.	Aquia Creek sandstone, (Patent Office,)	2093
15.	do. do. do. 2d specimen,	1875
16.	do. do. do. 3d do.	1441
17.	do. do. do. 4th do.	1234
18.	Common building brick,	1000

Arranging in order of the average strength, we have the following succession, a column of relative values being added in which the alum limestone is represented by 100.

		Average strength per square inch.	Relative value.
1.	Maryland fine-grained marble,	4481	192
2.	East Chester (N. Y.) marble,	3993	171
3.	Italian marble,	3156	135
4.	Patapsco granite,	2767	118
5.	Seneca (Smithsonian) stone,	2691	115
[6.	*Alum limestone* (monument),	2334	100]
7.	Stockbridge marble,	2251	96
8.	York-road freestone,	2125	91
9.	Aquia Creek (Patent Office) sandstone,	1660	71
10.	Common brick,	1000	42

Note.—The two sandstones, numbers 5 and 8, have a mean strength of 2408, which is three per cent. higher than that of the "alum limestone," which has its place between them in the above series. The four trials of the Aquia Creek sandstone give an average strength of 1660 pounds, and the first three experiments of Dr. Page on the alum limestone gave an average of 1521 pounds, showing the inferiority of at least some portions of this limestone to that "material which now disfigures the architecture of the Treasury building and the Patent Office."*

3. *Experiments on different building materials, published by Mr. Robert Mills*, architect of the Washington National Monument. Specimens of the same size as the preceding.

No. of trial.	Kind of stone.	Strength per square inch.	Relative value.
1.	Symington's fine-grain marble,	6344	271·
2.	Baltimore granite (Sumwalt and Grayson's),	6250	267·

* Hints on Public Architecture, p. 114.

No of trial.	Kind of stone.	Strength per square inch.	Relative value.
3.	Blue rock from Potomac, used as the backing stone of the National Monument,	3750	160
4.	Granite of the east (*Port Deposit*), .	3250	139
5.	Granite of Normandy,* . . .	2628	112
[6.	*Alum limestone* (monument), . .	2334	100]

4. *Marbles and limestones tested and Reported on by Mr. Rennie in England.*†

No. of trial.	Kind of stone.	Lbs. per sq. inch.	Relative value.
1.	White Italian veined marble (tried in 1½ inch cubes), ...	9681	414
2.	Black Brabant marble (tried in 1½ in. cubes,)	9281	395
3.	Purbeck stone, do.,	9160	392
4.	Black compact limestone, Limerick, Ireland, (tried in 1½ inch cubes,) . . .	8855	379
5.	Compact limestone, do., . . .	7713	330
6.	Devonshire red marble, do., . .	7187	308
7.	White statuary marble, not veined, do.,	6058	259
8.	White Italian veined marble, tried in one-inch cubes, ...	3216	137
[9.	*Alum limestone*, (as above,) . .	2334	100]

Note.—From his own reading of the original memoir of Mr. Rennie, the writer was led to suppose that all the above samples of stone, numbered from 1 to 6 inclusive, had been tested in two-inch cubes, and that the Numbers in the Philosophical Transactions (1818) referred to blocks of four square inches on the base; but in the Encyclopedia Britannica Mr. Tredgold has given the dimensions 2·25 square inches for the base. Barlow has apparently understood Mr. Rennie in the same way. On this latter area the above numbers are computed. On the supposition of a *four-inch base* they would stand as follows:—

No. 1. gave per sq. inch 5445 lbs.	No. 4. gave per sq. inch 4981 lbs.
" 2. " " 5185 "	" 5. " " 4338 "
" 3. " " 5152 "	" 6. " " 4178 "

These numbers change the relative values but they do not alter the position of the "alum limestone," which stands, as proved by Dr. Page, far below all the limestones and marbles, tested by Mr. Rennie, whether the latter were in 1, 1½ or 2-inch cubes.

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* See below some account of other granites of Normandy, tried in two-inch cubes by Rondelet.

† Transactions Royal Society, 1818.

5. Experiments by Mr. Rennie on granites, tested in 1½ inch cubes.

		Lbs. per sq. inch.	Relative value.
1.	Aberdeen blue granite, ...	10,913	467
2.	Peterhead hard close grained granite, .	8,282	354
3.	Cornish granite, ...	6,356	272
[4.	*Alum limestone*, as above, . . .	2,334	100]

6. *Mr. Rennie's experiments on sandstones.*

		Lbs. per sq. inch.	Relative value.
1.	Very hard freestone (1½-inch cubes), .	9446	404
2.	Dundee sandstone, breccia, do. . .	6630	284
3.	Bramley falls sandstone near Leeds, do. .	6063	259
4.	Craigleith white freestone, do. . .	5487	234
5.	Portland stone, do.	4570	195
6.	Killaly white freestone, do. . . .	4561	195
7.	Derby grit red friable sandstone, average of two varieties, do.	3743	160
8.	Portland stone in a 2-inch cube, . .	3729	159
[9.	*Alum limestone*, as before, . . .	2334	100]

Note.—The weakest of the above sandstones is 27 per cent. stronger than the strongest specimen of the "alum limestone" tried by Dr. Page.

7. *Experiments by Messrs. Daniel and Wheatstone*, on the magnesian limestone of Yorkshire, Derbyshire and Nottinghamshire in England, employed in building the new Houses of Parliament.* Tested in two-inch cubes, in duplicate.

		Lbs. per sq. inch.	Relative value.
1.	Stone of Kiveton, ...	10,695	458
2.	" Stone-ends, . . .	9,209	394
3.	" Bolsover Moor, . . .	8,288	355
4.	" Kiveton, 2d variety, . .	6,163	284
5.	" Norfall, ...	5,879	252
6.	" Steetley, yellow variety, .	5,171	221
7.	" Steetley, white do. . .	3,192	136
[8.	*Alum limestone of Maryland*, as before,	2,334	100]

Note.—The average strength of the seven varieties of stone above compared is exactly three times as great as that of the "alum limestone."

The stone used for the houses of Parliament is described as standing, in its natural site, high above the ground, in large masses or perpendicular walls, with its smooth, bleached, time-worn surface, discolored only by a few lichens with a little moss or ivy,—facts clearly indicating its strength and durability.

* See "Lithology, or observations on stone used for building," by C. H. Smith, p. 22.

8. *Experiments on Marbles, made in France by Rondelet, Gauthey, Sufflot and Perronet,** on two inch cubes, the weights and measures being reduced to English to conform to the other series.

		Lbs. per. sq. inch.	Relative val.
1.	Black marble of Flanders, . .	11,218	480
2.	Cervelas marble of Flanders, .	5,738	245
3.	White Statuary marble, . .	4,652	199
4.	Blue Turquin marble, . . .	4,328	185
5.	Veined white marble, . . .	4,241	181
6.	Veined white marble called Pauf, .	3,701	158
[7.	*Alum limestone of Md., as above,*	2,334	100]

Note.—With the exception of the first of the above trials the French experiments conform pretty nearly with those of Mr. Rennie on similar materials supposing the numbers given by the latter were obtained from two inch cubes; but they fall far below his results, admitting, with Tredgold, that his blocks were $1\frac{1}{2}$ inch cubes. Gregory appears to have understood that all Rennie's experiments were made on $1\frac{1}{2}$ inch cubes unless otherwise expressly stated.

9. *Experiments of Rondelet and other French experimenters on two-inch cubes of granite.*

		Lbs. per. sq. inch.	Relative value.
1.	Oriental rose granite, . .	12,518	536
2.	Granite of Normandy called *Champ du Bout*, . .	11,628	498
3.	Granite of Normandy called *Gallicien*, ...	9,987	428
4.	Granite of Bretagne, . .	9,303	398
5.	Green granite of Vosges, .	8,798	376
6.	Beola granite used in Milan, .	6,603	282
7.	Grey granite of Vosges, . .	6,020	257
[8.	*Alum limestone of Maryland,*	2,334	100]

The average relative value of the seven granites above cited is 396, or almost four times that of the "alum stone."

10. *Experiments on stones used in the construction of various ancient edifices,* reported by Rondelet,—size two inch cubes.

		Lbs. per. sq. inch.	Relative value.
1.	Caserté stone of Italy, . .	8,584	363
2.	Stone of Istria used by Palladio, Sancovino and Scamozze in the edifices of Venice and Vicenze,	7,395	316
3.	Fourneaux stone, pillars of All Saints Church at Angers, . .	6,317	270

* Traité theorique et pratique de l'art de bâtir. Par Jean Rondelet, tom. i. p. 211–214.

	Lbs. per sq. inch.	Relative value.
4. Grey stone of Florence, . .	6,096	261
5. Stone of the bridge of St. Maxence,	5,404	231
6. Travertin, material of ancient Roman buildings, ...	4,301	183
7. Bagneaux stone, columns of the Pantheon, Paris, . . .	3,484	149
8. Stone of the temple of Paestum,	3,258	130
[9. *Alum limestone, Maryland*, .	2,334	100·]

The average relative value of these ancient building stones is 238.

11. *Experiments on two-inch cubes of Basalt and Porphyry, by Gauthey and Rondelet*, reported by the latter in the work above cited.

	Lbs. per sq. inch, (Eng.)	Relative value.
1. Basalt of Auvergne, . .	29,549	1266
2. Porphyry, . . .	28,455	1219
3. Swedish basalt, . . .	27,196	1165
4. Basalt of Auvergne, 2d variety,	25,172	1078
5. do. do. 3d variety,	16,416	703
[6. *Alum limestone*, . .	2,334	100]

The average relative value of the basalts and porphyries is 1086.

12. *Experiments on the alum limestone of Maryland* in blocks of other dimensions than two inch cubes, published by Mr. Dougherty, the Superintendent of the Washington National Monument, as having been made at the Navy Yard, Washington.

	Per square inch of base.	Average.
1. A 1-inch cube (1 sq. inch base),	2000	
2. Another block of the same size, do.	2000	Expt. 1 and 2,—2000
3. A cube of 3½ inches on a side, (12¼ base,)	3265	
4. Another cube of same size, do.	3765	Expt. 3 and 4,—3515
5. A slab 4¾ inches square, 2 inches thick, (22·56 base,)	5629	
6. do. 4¾ square, 4¾ inches high, do.	2659	
7. A 4-inch cube, (16 inch base,)	5687	Expt. 5 and 7,—5658

The 6th experiment is alledged to have been made on a block of unequal thickness and therefore not to give a fair result.

The first two of the above experiments give results considerably below the average of Dr. Page's trials on two-inch cubes. The only standard with which we can at present compare them, is the one inch cube of Italian veined marble tried by Mr. Rennie, which gave 3216·lbs. per square inch. Their relative values, by this comparison, are 100 and 160. Comparing the three averages above given, there is an evident increase of strength per square inch of base, dependent apparently in some measure on the increased size of the specimens.

We are furnished by the paper of Mr. W. Wyatt of England, with a considerable series of experiments on marbles, granites,

and sandstones, tested in cubes of about the same size as the largest of those above given. His investigations were made with the aid of the hydraulic press of Messrs. Bramah & Sons, and in this respect also appear to be comparable with those, made on the alum limestone in large blocks. Each of his results is the mean of two trials*.

13. ***Mr. Wyatt's experiments on marbles, in blocks of larger size than 2-inch cubes.***

	Lbs. pr. sq. inch.	Rel. value.
1. Ravaccioni marble, (blocks $4\frac{1}{2}\times4$ inches base), . .	9632	172
2. Veined marble (" $4\frac{1}{2}\times4$ " . . .	9251	163
[3. *Alum limestone in 4, and in $4\frac{3}{4}$ inch cubes* (average), .	5658	100]

From the above and the preceding series of trials, it appears that the "*alum limestone*" falls very far below Italian marble, whether tested in 1-inch, 2-inch, or 4-inch cubes, and whether crushed under a hydraulic press, or any of the other carefully constructed machines which have been employed for the purpose in France and England. Compared with every other good marble and limestone, its inferiority of strength, when the size of cubes was the same, appears still more remarkable.

14. ***Mr. Wyatt's experiments on granites tested in cubes of 4 inches on a side, or in blocks of which the base measured 4·5 by 4 inches.***

	Lbs. pr. sq. inch.	Rel. value.
1. Herm granite, (4-inch cubes), . . .	14,873	262
2. Heytor do. do. . . .	13,865	245
3. Dartmoor granite, do. . . .	12,275	217
4. Peterhead red do. ($4\cdot5\times4$ inch base), .	10,931	193
5. Aberdeen blue do. ($4\cdot25\times4$ do.) . .	10,393	183
6. Peterhead blue gray do. ($4\cdot5\times4$ do.) .	9,766	172
7. Penryn granite, ($4\cdot5\times4$ do.) . .	7,728	136
[8. *Alum limestone*, (in 4 and in $4\frac{3}{4}$ cubes), .	5,658	100]

15. ***Mr. Wyatt's experiments on sandstones,*** tested in cubes of $5\frac{1}{2}$ and 6 inches on a side.

	Lbs. pr. sq. inch.	Rel. val.
1. Yorkshire Cromwell stone (5·5 inch cubes)	8,825	156
2. Craigleith stone (6 inch cubes), . .	6,652	117
3. Humbie stone do. . . .	4,614	81
4. Whitby sandstone do. . . .	2,374	41
[5. *Alum limestone* (4 and 4·75 cubes), . .	5,658	100]

The average strength of the above four sandstones is almost identical with that of the *alumstone*, as given by these experiments. Had the cubes been 4 instead of 6 inches, the comparison might probably have been more favorable to the alumstone. Its true position in the scale of strength, among building stones,

* See Transactions of the Society of Civil Engineers, vol. i, p. 235.

as proved both by Dr. Page and Mr. Wyatt, is among the *sandstones*, not among granites, marbles or compact limestones.

16. In addition to the foregoing comparisons, the writer is enabled to add two experiments of his own on the Quincy syenite, the stone of which the Bunker Hill Monument is built. These experiments were made July 28, 1843.

	Lbs. pr. sq. inch.	Rel. value.
1. A 1·5 inch cube (2·25. sq. inch base), bore . . .	15,929	682
2. A block having a base 2·5×1·15=2·87 sq. inches and a length of 5·25 inches, proved endwise, bore . .	12,390	530
[3. *Alum limestone*—Dr. Page's trials on 2 inch cubes, .	2,334	100]

Note.—The block proved by compressing it endwise was not crushed, but only splintered or slightly "spalled" along the corners. This was done at two successive applications of the same compressing force. The 1·5 inch cube was crushed with the force above given.

From these experiments it appears that the Bunker Hill Monument stone is possessed of a strength intermediate between *Oriental rose granite*, and *Auvergne basalt*, as given by M. Rondelet.

That a coarse, loosely aggregated rock like the alumstone, is far inferior in strength to rocks of the same chemical constitution and specific gravity but of fine texture, was long since proved by Rondelet. We may cite one or two of his proofs and add by way of comparison, two others derived from the preceding sections of this paper.

17. *Experiments on coarse, and on fine-grained stones of the same class.* Specimens tried in two-inch cubes.

1.	Roussard stone, *coarse* grained, ...	3957
	Choin de Villeburg, *fine* grained, ...	8300
2.	Saillan court stone, *coarse* grain, ...	2062
	Stones of Passy and Vaugirard, *fine* grain, ...	4484
3.	Symington's *coarse alum limestone*, (11 trials by Dr. Page,) .	2334
	Symington's fine grain marble, (2 do. do. . .	4484
4.	*Alum limestone*, highest of Dr. Page's results, . . .	2968
	Fine grain marble, highest result by Mr. Mills, ...	6344

The average strength of the four coarse-grained stones is 2830, that of the four fine grained ones, 5982. The ratio of these numbers is 100 to 211.

Arranging the several kinds of stone in the order of their relative values as determined by their power to resist crushing, and placing against each the number of square inches on the base of the specimens tried, with the name of the experimenter, we have the following rank, as indicated by a comparison with the *alum limestone* used in casing the Washington National monument, the strength of which is taken as 100.

No.	Name of stone.	Area of base of specimens in sq. inches.	Name of experimenter.	Rel. val. Alumstone = 100.
1.	Basalt of Auvergne,	4	Rondelet,	1266
2.	Porphyry,	4	do.	1219
3.	Swedish basalt,	4	do.	1165
4.	Auvergne basalt, 2d variety,	4	do.	1098
5.	do. do. 3d variety,	4	do.	703
6.	Quincy syenite, 1½ inch cube,	2·25	Johnson,	682
7.	Oriental rose granite,	4	Rondelet,	536
8.	Quincy syenite, long block,	2·87	Johnson,	530
9.	Granite of Normandy, *Champ du Bout*,	4	Rondelet,	498
10.	Black marble of Flanders,	4	do.	480
11.	Aberdeen blue granite,	2·25 (?)	Rennie,	467
12.	Kiveton dolomite,	4	Daniel & Wheatstone.	458
13.	Granite of Normandy, *Gallicien*,	4	Rondelet,	428
14.	White Italian veined marble,	2·25 (?)	Rennie,	414
15.	Very hard freestone,	2·25	do.	404
16.	Granite of Bretagne,	4	Rondelet,	398
17.	Brabant black marble,	2·25 (?)	Rennie,	395
18.	Dolomite from Stonends,	4	Daniel & Wheatstone.	394
19.	Purbeck stone,	2·25 (?)	Rennie,	392
20.	Compact black limestone of Limerick,	2·25 (?)	do.	379
21.	Green granite of Vosges,	4	Rondelet,	376
22.	Caserté stone of Italy,	4	do.	363
23.	Bolsover Moor dolomite,	4	Daniel & Wheatstone.	355
24.	Peterhead close-grained granite,	2·25 (?)	Rennie,	354
25.	Compact limestone,	2·25 (?)	do.	330
26.	Istria stone,	4	Rondelet,	316
27.	Devonshire red marble,	2·25 (?)	Rennie,	308
28.	Kiveton dolomite, 2d variety,	4	Daniel & Wheatstone.	284
29.	Dundee sandstone,	2·25	Rennie,	284
30.	Beola granite, Milan,	4	Rondelet,	282
31.	Cornish granite,	2·25	Rennie,	272
32.	Symington's fine-grained stone,	4	Mills,	271
33.	Fourneaux stone, Angers,	4	Rondelet,	270
34.	Baltimore granite,	4	Mills,	267
35.	Herm granite,	16	Wyatt,	262
36.	Greystone of Florence,	4	Rondelet,	261
37.	Bramley Falls sandstone, Leeds,	2·25	Rennie,	259
38.	Statuary marble not veined,	2·25	do.	259
39.	Grey granite of Vosges,	4	Rondelet,	257
40.	Norfall dolomite,	4	Daniel & Wheatstone.	252
41.	Heytor granite,	16	Wyatt,	245
42.	Cervelas marble of Flanders,	4	Rondelet,	245
43.	Craigleith white freestone,	2·25	Rennie,	234
44.	Bridge of St. Maxence stone,	4	Rondelet,	231
45.	Steetley yellow dolomite,	4	Daniel & Wheatstone.	221
46.	Dartmoor granite,	16	Wyatt,	217
47.	White statuary marble,	4	Rondelet,	199
48.	Portland stone,	2·25	Rennie,	195
49.	Killaly white freestone,	2·25	do.	195
50.	Peterhead red granite,	18	Wyatt,	193
51.	Symington's Maryland fine-grained stone,	4	Page,	192
52.	Blue Turquin marble,	4	Rondelet,	185
53.	Travertin of Ancient Rome,	4	do.	183
54.	Aberdeen blue granite,	17·5	Wyatt,	183
55.	Veined white marble,	4	Rondelet,	181
56.	Peterhead blue-grey granite,	18	Wyatt,	172
57.	Ravaccioni marble,	18	do.	172
58.	East Chester marble, N. Y.,	4	Page,	171
59.	Veined marble,	18	Wyatt,	163

TABLE CONTINUED.

No.	Name of stone.	Area of base of specimens in sq. inches.	Name of experimenter.	Rel. val. Alum-stone = 100.
60.	Metamorphic blue Potomac stone,	2·25	Mills,	160
61.	Derby grit, friable sandstone,	2·25	Rennie,	160
62.	Portland stone,	4	do.	159
63.	Veined white marble, (Pauf,)	4	Rondelet,	158
64.	Yorkshire Cromwell stone,	30·25	Wyatt,	156
65.	Bagneaux stone, (Pantheon at Paris,)	4	Rondelet,	149
66.	Granite of Port Deposite,	4	Mills,	139
67.	White veined Italian marble,	1	Rennie,	137
68.	Steetley white dolomite,	4	Daniel & Wheatst'ne	136
69.	Penryn granite,	18	Wyatt,	136
70.	Italian marble,	4	Page,	135
71.	Temple of Paestum stone,	4	Rondelet,	130
72.	Patapsco granite,	4	Page,	118
73.	Craigleith sandstone,	36	Wyatt,	117
74.	Seneca sandstone, Smithsonian Institute,	4	Page,	115
75.	Granite of Normandy,	4	Mills,	112
76.	*Alum limestone,* (Wash'gton Nat'nal. Mon't.)	4	Page,	100
77.	Stockbridge marble,	4	do.	96
78.	York road brown sandstone,	4	do.	91
79.	Humbie sandstone,	36	Wyatt,	81
80.	Aquia Creek (Patent Office) sandstone,	4	Page,	71
81.	Whitby sandstone,	36	Wyatt,	41

The wide discrepancy already noted between the results obtained in experimenting on the alum limestone, in which the pressure required for crushing varied from 910 pounds to 5687 pounds per square inch of the area of the base, must be explained either on one or the other of three suppositions; 1st, that the strength of different specimens of the rock is thus variable, and that consequently no certain reliance could be placed on its powers of resistance; or 2nd, that the experimenting or the machine with which it was conducted was faulty; or 3rd, that the resistance to crushing for a unit of area at the base, increases in some ratio with the number of units composing that area, that is, with the actual area of the base. The experiments published by Mr. Dougherty show discrepancies nearly as wide as those previously made by Dr. Page, beginning however with 2000 pounds on a one-inch cube, and ending with 5687 pounds per square inch on a four-inch cube, instead of beginning with 910 pounds and ending with 2968 pounds on two-inch cubes.

With a view to trace some relation, if such exist, between the increase of area of base and the power of resistance of cubes of granular rocks and other materials, the writer has proposed a series of trials on several stones, in cubes of different sizes from one to six inches on a side, all those of the same kind of stone to be taken from the same block and accurately reduced to the respective dimensions. At present the following comparisons *seem* to point to a direct relation between the power of resistance of the cube and the product of the ***area of the base multiplied into the cube root of that area.***

1. The one-inch cubes of alum limestone gave Mr. Dougherty two thousand pounds, and the 4·75 inch cube, having 22·56 square inches on the base, gave 5629 pounds per square inch. In comparing these with the cube roots of the areas of base we have $\sqrt[3]{1} : \sqrt[3]{22{\cdot}56} :: 2000 : 5652$ or the calculated exceeds the experimental result by only twenty three pounds, or 0·4 per cent.

2. A two-inch cube of the alumstone in Dr. Page's third experiment gave per square inch of base 2281 pounds, and a $3\frac{1}{2}$ inch cube in Mr. Dougherty's third experiment, gave 3265 pounds per square inch. Comparing these we have $\sqrt[3]{4} : \sqrt[3]{12{\cdot}25} :: 2281 : 3312$ showing that the calculated exceeds the experimental result by 47 pounds or about one and a half per cent.

3. The seventh experiment of Dr. Page gave 2625, and the fourth of Mr. Dougherty gave 3765, consequently $\sqrt[3]{4} : \sqrt[3]{12{\cdot}25} :: 2625 : 3812$, in which the calculated exceeds the experimental by forty-two pounds, or $1\frac{1}{16}$ per cent.

4. Mr. Dougherty's first and second experiments on one inch cubes gave 2000 pounds, and Dr. Page's eleventh experiment on two-inch cubes gave 2968. Hence $\sqrt[3]{1} : \sqrt[3]{4} : 2000 : 3156$ where calculation exceeds experiment by two hundred and seven pounds, or 6·9 per cent.

5. Comparing Dr. Page's eleventh experiment with Mr. Dougherty's fifth, in which a block $4\frac{3}{4}$ inches on a side bore 5629 pounds per square inch, we have $\sqrt[3]{4} : \sqrt[3]{22{\cdot}56} :: 2968 : 5283$, in which calculation falls short of experiment by 346 pounds or about 6 per cent.

6. Mr. Rennie's eighth trial on marbles, showed that a one inch cube of white Italian marble bore 3216, and M. Rondelet on a two inch cube of the same, obtained per square inch, 4651 pounds. Hence $\sqrt[3]{1} : \sqrt[3]{4} :: 3216 : 5106$, the calculated exceeding the experimental result by 455 pounds, or nearly 9 per cent.

7. By our reading of Mr. Rennie's memoir, he obtained from a two inch cube of Italian veined marble, 5445 pounds per square inch, and Mr. Wyatt obtained from a $4\frac{1}{2}$ by 4 inch block, 9251 pounds. Here, $\sqrt[3]{4} : \sqrt[3]{18} :: 5445 : 8990$ differing in defect from the experimental result by 261 pounds, or less than 3 per cent.

8. If Mr. Rennie's experiment on Aberdeen granite was, as we suppose, also on a two inch cube, its strength per square inch was 6139 pounds, and as Mr. Wyatt obtained from Aberdeen granite, when tried in blocks $4\frac{1}{2} \times 4$ inches on the base, a strength of 10,393 pounds, we have $\sqrt[3]{4} : \sqrt[3]{18} :: 6139 : 10{\cdot}130$ where the calculated falls short of the experimental result by 263 pounds $= 2\frac{1}{2}$ per cent.

9. Mr. Rennie proved Cornish granite in one and a half inch cubes to have a strength per square inch of 6356, and Mr. Wyatt on a four inch cube of Dartmoor granite, obtained 12,275 pounds.

Now $\sqrt[3]{2{\cdot}25} : \sqrt[3]{16} :: 6356 : 12{,}420$ making the calculated to exceed the experimental result by 145 pounds or $1\frac{1}{10}$ per cent.

10. Mr. Rennie tried five blocks of cast iron of $\frac{1}{8}$th inch square base and $\frac{1}{8}$th to $\frac{3}{8}$th high and found the crushing force 1710 pounds per one-eighth. He also tried thirteen cubes of $\frac{1}{4}$th inch, and found the average 2600 pounds per one-eighth inch base. In this case $\sqrt[3]{1} : \sqrt[3]{4} :: 1710 : 2712$, showing the calculated to exceed the experimental result by 112 pounds, or about 4 per cent.

It is not alledged that these ten cases conclusively establish the law, but they seem to afford a pretty strong presumption in its favor; and though it is true that these cases are for want of certainty as to the perfect similarity of specimens compared, liable to some objection, yet they appear to warrant a series of experiments of the kind above proposed. Should the law not be thereby confirmed, one of the other explanations of the discrepancies in the strength of "alum limestone" must be resorted to.

ART. II.—*On the Law of the Induction of an Electric Current upon itself when developed in a straight prismatic conductor, and of discharges of Machine Electricity through straight wires;** by J. H. LANE, of the U. S. Patent Office.

THE original discovery of the induction of electric currents was made by Prof. Faraday, about twenty years since. Prof. Henry followed up the subject in the very elegant and elaborate series of experiments, detailed in his "Contributions to Electricity and Magnetism," published in the Journal of Science for 1840 and 1841, and the full and able discussion of those experiments in the same papers presents the most complete elucidation of the laws of the induction of electric currents that has yet appeared. Prof. Henry added the interesting discovery of the induction of an electric current upon itself, and showed that this too could be referred to the single principle of the inductive action of the primary current upon a neighboring conductor. The simple laws to which he refers all the phenomena yet observed are laid down by him in these three propositions.

"1. During the time a galvanic current is increasing in quantity in a conductor, it induces or tends to induce, a current in an adjoining parallel conductor, in an opposite direction to itself.

"2. During the continuance of the primary current in full quantity, no inductive action is exerted.

"3. But when the current begins to decline in quantity, and during the whole time of its diminishing, an induced current

* The principal results contained in this paper were read before the National Institute at Washington, and subsequently communicated through a scientific friend to the American Association at their meeting in New Haven, in August, 1850.

is produced in an opposite direction to the induced current at the beginning of the primary current."

My purpose in this paper is to present certain deductions from these laws in reference to the induction upon itself of an initial electric current moving in a straight conductor. In arriving at these deductions however it will be necessary to add to the laws above enunciated, one or two farther hypotheses as to the variation of the inductive force at different distances and in different positions of the primary current, which hypotheses are however too plainly suggested by the analogies furnished by other well established laws of electricity to admit of very serious doubt. Still they cannot be regarded as established by direct experiment, but are open to future investigation, and if the few results I venture now to make public shall be found to afford any facility to such an investigation, one object of this paper will have been attained.* The very simple and sufficiently elegant analytical result arrived at in the solution of what at first seemed a difficult problem, has also furnished an additional motive with me for its publication.

1. Prof. Henry's laws, with the hypotheses assumed as the basis of the present investigation, may be summed up in the following enunciation.

The inductive force exerted at a given point by the development of an electric current in an infinitely short element of an infinitely attenuated conducting wire, is directly proportional to the rapidity with which the current increases in quantity (or the rate of development) and to the length of the element multiplied into the natural sine of the angle it makes with the line drawn from it to the given point, and inversely proportional to the square of that line; and in a direction at right angles to the same in the plane of the element, but contrary to the direction of the developed or primary current.

Let *ab*, fig. 1, be an infinitely short element of an electric current flowing with increasing rapidity in the direction of the arrow, and let *c* be any point within the space of its sensible action: join *bc* and draw the perpendicular *af*. We have the analogy of the dynamical action of galvanic currents for believing that the inductive effect of the elementary current will be the same whether it move through the straight line *ab* or through the route *afb*. But in the latter case it is nearly certain that the part *fb* will have no effect at *c* in any direction transverse to the line *cb*, there

1.

* The most serious question, it appears to me, that can be raised in regard to these deductions respecting the nature of the induction of a current upon itself, is whether the action designated by that name is really due, as Prof. Henry believes, to inductive action at a distance only, or may not be partly due to a different species of action more strictly analogous to inertia in ponderable matter. The former supposition is more in accordance with the simplicity of nature's operations, and at present there is not, so far as I am aware, any special reason to doubt its correctness. Nevertheless, I hope to be able to settle the question hereafter by experiment.

being no reason why there should be more of such action in one direction than another (i. e., on one side of *cb* rather than another) except on the extreme supposition of the inductive action being dependent on or connected with the influence of surrounding bodies which there is not the slightest reason to suspect; if, therefore, *fb* exerted any influence at all we should from the nature of the case expect to find it in the direction of *cb* only, and there is not the first fact yet known that indicates any action in that direction. In reference to the dynamic action of the current after it is established we know with all reasonable assurance that *fb* is not felt at *c*. There remains then the influence of the part $af = ab \sin abc$, and we may assume, also, from the analogy of the known law of the dynamic action, that its action is directly proportional to its length and inversely proportional to cb^2 and also directly proportional to the rate of development of the current in *afb* or in *ab*. All experiments moreover indicate that the direction of the inductive force is at right angles to *cb* and in the plane *abc*.

2. It may be well to state before going farther that in the use of the term inductive force, I have no reference whatever to the secondary current that may result from the exertion of that force. Whenever an electric current is generated in a conductor an inductive force is exerted at any point in the neighborhood, and if the medium in which it is exerted be a conductor of electricity a current will be produced; if not no current can take place, but the force does not the less really exist, and is as really measurable as a mechanical force though it would be too much to assert that it is a mechanical force. It is of course to be estimated like every electro-motive force without reference to the transverse extent of the elementary space in which it is exerted, but solely with reference to its longitudinal extent in the direction of the force, in the same manner as we estimate the intensity of the pressure of a column of water according to its perpendicular height alone.

3. Returning now to the fundamental law just premised let q represent the quantity of current flowing in *ab* at the end of the time t from a given instant: $\frac{\mathrm{d}q}{\mathrm{d}t}$ will then represent the rate of development of the current. Also let the distance $cb = D$ and let $l =$ the length of the electric conductor of which *ab* is an element so that $ab = \mathrm{d}l$ and let the angle $abc = \theta$. Then the inductive force exerted by *ab* at *c* in the direction as above stated of *cd* will be proportional to

$$\frac{\mathrm{d}q}{\mathrm{d}t} \frac{\sin \theta \mathrm{d}l}{D^2}$$

This formula will embrace the 2d and 3d of the above quoted enunciations of Prof. Henry, if $\mathrm{d}q = 0$ for a constant current and be considered negative when the current is diminishing in quantity. If we wish to estimate the inductive force in the direction

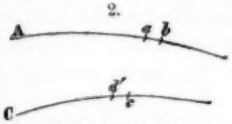
of a line cd' which makes with cd the angle τ either in the plane abc or out of it, we must resolve the force in the direction of cd in the same manner as any other electro-motive force or as a mechanical force, so that if M represent the whole force in the direction of cd and M' the resolved force in the direction of cd' we shall have $M' = M \cos \tau$.

Thus we shall finally have the inductive force exerted at c in the direction of cd' proportional to

$$\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\,\frac{\cos\tau \sin\theta\,\mathrm{d}\,l}{D^2}.$$

4. This regards the inductive force as exerted at a single point, but all experiments show that it accumulates along the secondary conductor in proportion to its length. Let $A\,b$, fig. 2, be the primary conductor and $c\,C$ the secondary, and let I represent the whole inductive force exerted by $A\,a$ on the whole secondary $c\,C$ of which the length $= s$. Then the whole inductive force exerted on the element $cd' = \mathrm{d}\,s$ (and which may be safely assumed to be proportional to cd') will be expressed by $\frac{\mathrm{d}\,I}{\mathrm{d}\,s}\,\mathrm{d}\,s$, and that exerted on cd' by ab will have for its expression $\frac{\mathrm{d}^2 I}{\mathrm{d}\,s\,\mathrm{d}\,l}\,\mathrm{d}\,s\,\mathrm{d}\,l$. Hence we shall have

2.

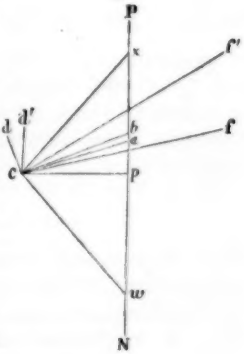


$$\text{(A)} \qquad \frac{\mathrm{d}^2 I}{\mathrm{d}\,s\,\mathrm{d}\,l} = C\,\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\,\frac{\cos\tau \sin\theta}{D^2}.$$

This equation then in which C represents a constant whose value has never yet been determined by experiment, is the general differential equation for the induction of electric currents so far as concerns the relation of primary and secondary linear conductors to each other.

The lines l, D, and s and circular functions $\cos\tau$ and $\sin\theta$ may readily be referred to rectangular coordinates in space, but for my present purpose this is not necessary.

3.



5. From (A) it readily follows that,

If an electric current be developed in a straight wire of unlimited length so small that it may be regarded as a line, the force of induction in a direction parallel with the wire at any given point will be inversely as the perpendicular distance of that point from the wire.

Let PN, fig. 3, be the straight conducting wire and let cd' be the given

element of space parallel to PN in which the inductive force is to be exerted, and let *ab* be an element of PN. Draw the perpendicular *cp* and let $cp=r$, and let θ' represent the angle *pca*, the complement of *pac* or θ. It being understood that *cp* is the origin of the angle θ' and *p* the origin of l, we have in applying the formula (A)

$$\tau=dcd'=\theta' \qquad l=pa=r\tan\theta'$$

$$D=ca=r\sec\theta' \qquad \mathrm{d}\,l=r\frac{\mathrm{d}\,\theta'}{\cos^2\theta'}$$

The substitution of these values in (A) gives us,

$$\frac{\mathrm{d}^2 I}{\mathrm{d}\,s\,\mathrm{d}\,l}\mathrm{d}\,l=\frac{C}{r}\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\cos^2\theta'\,\mathrm{d}\,\theta'$$

and the integration of this with reference to θ' gives us for the whole inductive force exerted in the elementary space *cd'* or $\mathrm{d}\,s$ in the direction of the latter by the current in *pa*

$$\frac{\mathrm{d}\,I}{\mathrm{d}\,s}\mathrm{d}\,s=\frac{C}{r}\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\mathrm{d}\,s\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta'$$

or still dividing by $\mathrm{d}\,s$ we shall retain in what follows only the coëfficient $\frac{\mathrm{d}\,I}{\mathrm{d}\,s}$ calling it the inductive force at the *point c* parallel with PN, and in the present instance therefore we have

$$\text{(B)} \qquad \frac{\mathrm{d}\,I}{\mathrm{d}\,s}=\frac{C}{r}\frac{\mathrm{d}\,q}{\mathrm{d}\,t}\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta'$$

in which if the limits of integration be constant the value of the second member is inversely as r. Hence if any two radial lines as *cf*, *cf'* be drawn, the induction in the *direction cd'* due to that part of the conductor PN cut off by those radial lines is inversely proportional to the distance *cp*.

6. Carrying out the integration indicated in the preceding formula we have

$$\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta'=\tfrac{1}{2}(\eta'-\eta)+\tfrac{1}{4}(\sin 2\eta'-\sin 2\eta)$$

and if, by including a great length of conductor on both sides of *p* the limits η and η' be made closely to approach the values of $+\frac{1}{2}\pi$ and $-\frac{1}{2}\pi$ so that $\eta=-(\frac{1}{2}\pi-h)$ and $\eta'=+(\frac{1}{2}\pi-h')$ where h and h' are very small arcs, we have

$$\int_{\eta}^{\eta'}\cos^2\theta'\,\mathrm{d}\,\theta=\tfrac{1}{2}\pi-\tfrac{1}{4}(2h'-\sin 2h')-\tfrac{1}{4}(2h-\sin 2h)$$

which expression differs from $\frac{1}{2}\pi$ only by a small quantity of the third order, so that if the conductor be extended till it subtends an angle *wcx* closely approaching 180°, the inductive force due to all beyond that limit will be insensible* in practice, the value of $f\cos^2\theta'\,\mathrm{d}\theta'$ remaining nearly constant. Hence, what was stated of that part of the conductor included in a fixed angle *fcf'*, may be affirmed also of a determinate length *wx* of the conductor so long as the distance *cp* is very small compared with either *px* or *pw*, that its inductive action parallel to itself is inversely as the distance, and this action is expressed thus

$$\text{(C)} \qquad \frac{dI}{\mathrm{d}s} = \tfrac{1}{2}\frac{C}{r}\frac{\mathrm{d}q}{\mathrm{d}t}\pi.$$

7. The expression for the induction at right angles to *c d'* or in the direction of *pc* will be identical with that for the induction in the direction of *cd'*, except that instead of the circular function $\int_{\eta}^{\eta'} \cos^2\theta'\,\mathrm{d}\theta'$ in equation (B) we shall have

$$\int_{\eta}^{\eta'} \sin\theta'\cos\theta'\,\mathrm{d}\theta' = \tfrac{1}{2}(\sin^2\eta' - \sin^2\eta)$$

which is necessarily zero or insensible when the limits η and η' are equal and of contrary signs or when each differs very little from $\frac{1}{2}\pi$, whence it follows that for any portion of the conductor bisected in the point *p*, or for any portion extending to a very great distance on both sides of *p*, the induction in the direction of *pc* is nothing or insensible. The phenomenon known in machine electricity as the lateral discharge, cannot be considered at variance with this statement, as that is readily explained without reference to the existence of an inductive force in *that direction* of the kind now under consideration.

Induction of an electric current upon itself, when developed in a straight prismatic conductor of great length.

8. I have already stated that Prof. Henry was the discoverer of the induction of a current upon itself, and that he was the first to refer it to the primary law of induction at a distance. A conductor of an electric or galvanic current may be regarded as constituted of a bundle of numerous very attenuated fibres, each conducting part of the current, and feeling, during the development, the inductive influence of the currents developed in all the other fibres.

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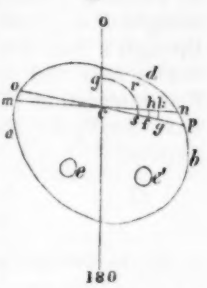
* Similarly it may readily be shown that if the current be returned into itself through a return circuit passing everywhere at a great distance the inductive force due to the return circuit will be insignificant.

Let *abd*, fig. 4, represent a cross section taken at a distance from either extremity of a prismatic conductor of great length in which a current of electricity is being developed, and let the conductor be supposed to be divided longitudinally into infinitely small elementary prisms or fibres. If a bundle of these fibres be taken whose cross section is the figure *e*, the portion of current conducted by the bundle may be distinguished as the current *through the figure or area e*. We shall first suppose the development of current to be equally rapid through all parts of the cross section of the conductor (i. e., through any two spaces *e*, *e'*, of equal area), and compare the magnitudes of the inductive forces at different points of the cross section *abd*.

4.



9. Let *c* be the point at which the inductive force is to be estimated. Through *c* draw the straight lines *mcn* and *ocp*, making with each other an infinitely small angle $ncp = \mathrm{d}\varphi$. Let *fg* be an infinitely short line taken in any part of *cp* or *oc* and draw the perpendiculars *fh* and *gk*. The inductive force exerted at *c* by the current through the area *fk* is given by formula (C). If Q represent the quantity of current passing at a given instant through a unit of sectional area, the quantity q passing through *fk* will be

$$q = Q \times \text{ area } fk \text{ and } \frac{\mathrm{d}q}{\mathrm{d}t} = \text{ area } fk \times \frac{\mathrm{d}Q}{\mathrm{d}t}.$$

Also $cf = r$, $fg = \mathrm{d}r$, $fh = r\,\mathrm{d}\varphi$, area $fk = r\,\mathrm{d}r\,\mathrm{d}\varphi$, and if we denote the whole inductive force exerted at *c*, in a fibre of the length s, by the current through any portion of *cgrs* of the cross section, by P, we shall have $I = \dfrac{\mathrm{d}^2 P}{\mathrm{d}r\,\mathrm{d}\varphi}\,\mathrm{d}r\,\mathrm{d}\varphi$.

Substituting these values in (C), we have for the inductive force exerted at *c* by the current through *fk*

$$\text{(D)} \qquad \frac{\mathrm{d}I}{\mathrm{d}s} = \frac{\mathrm{d}^3 P}{\mathrm{d}s\,\mathrm{d}r\,\mathrm{d}\varphi}\,\mathrm{d}r\,\mathrm{d}\varphi = \tfrac{1}{2}C\pi\,\frac{\mathrm{d}Q}{\mathrm{d}t}\,\mathrm{d}r\,\mathrm{d}\varphi.$$

As Q and consequently $\dfrac{\mathrm{d}Q}{\mathrm{d}t}$ is at present supposed to be the same for all parts of the section *abd*, it follows from (D) that the inductive force due to the current through *fk* is simply proportional to the magnitude of the elementary angle *ncp* and to the length of *fg*, independently of its distance from *c*, and that the whole force due to the current through the triangular spaces *ncp* and *mco* is

$$\text{(E)} \qquad \frac{\mathrm{d}^2 P}{\mathrm{d}s\,\mathrm{d}\varphi}\,\mathrm{d}\varphi = \tfrac{1}{2}C\pi\,\frac{\mathrm{d}Q}{\mathrm{d}t}\,E\,\mathrm{d}\varphi,$$

in which E represents the length of the chord *mn*. Now if a straight line revolve about the point *c* from the position 0 – 180, through a half revolution it will describe all the elementary triangles *mco* and *pcn* that make up the section *abd*. Therefore integrating (E) between the limits of $\varphi = o$ and $\varphi = \pi$, we have finally for the inductive force exerted at *c* by the whole current

$$\text{(F)}, \qquad \frac{\mathrm{d}P}{\mathrm{d}s} = \tfrac{1}{2} C \pi \frac{\mathrm{d}Q}{\mathrm{d}t} \int_o^\pi E \, \mathrm{d}\varphi,$$

10. If the rate of development $\frac{\mathrm{d}Q}{\mathrm{d}t}$ be not constant through all parts of the section *abd*, then $\frac{\mathrm{d}Q}{\mathrm{d}t} E$ in equations (E) and (F) must be replaced by

$$\int_{-\lambda}^{+\lambda} \frac{\mathrm{d}Q}{\mathrm{d}t} \, \mathrm{d}r$$

in which λ and λ' denote the values of *mc* and *cn*, and the equations (E) and (F) become

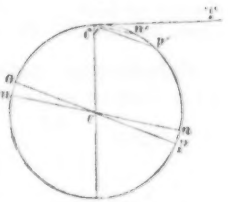
$$\text{(E')}, \qquad \frac{\mathrm{d}^2 P}{\mathrm{d}s} \mathrm{d}\varphi = \tfrac{1}{2} C \pi \left(\int_{-\lambda}^{+\lambda'} \frac{\mathrm{d}Q}{\mathrm{d}t} \mathrm{d}r \right) \mathrm{d}\varphi, \text{ and}$$

$$\text{(F')}, \qquad \frac{\mathrm{d}P}{\mathrm{d}s} = \tfrac{1}{2} C \pi \int_o^\pi \left(\int_{-\lambda}^{+\lambda'} \frac{\mathrm{d}Q}{\mathrm{d}t} \mathrm{d}r \right) \mathrm{d}\varphi.$$

Comparison of the inductive forces at the centre and surface of a long cylindrical conductor, when the development is uniformly rapid throughout its mass.

11. Let fig. 5, represent the cross section of a cylindrical conductor or wire of a great length in comparison with the diameter, which we will call $2R$, and let us suppose a current to be developed with equal rapidity through all parts of the section. Then in finding the whole inductive force at the centre *c* by formula (F) we have the chord E always a diameter or $= 2R$, and consequently

5.



$$\int_o^\pi E \, \mathrm{d}\varphi = 2\pi R,$$

while for the point *c'*, the chord $c'n' = 2R \sin T'c'n'$ or $E = 2R \sin \varphi$, and

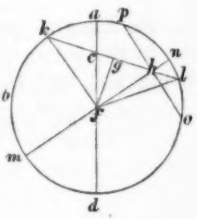
$$\int_o^\pi E \, \mathrm{d}\varphi = 2R \int_o^\pi \sin \varphi \, \mathrm{d}\varphi = 4R.$$

The inductive forces at the centre and circumference are therefore as $\pi : 2$, or as the semi-circumference of a circle to its diameter. This would lead us to expect the initial development of an electric current in a wire at the first instant of the application of an electro-motive force, acting as is usually the case with equal intensity through all parts of the cross section, to be more rapid at the surface than at the centre, for the inductive force must be exactly sufficient at every point to balance the force applied.

Equilibrium of the initial inductive forces within the mass of a straight cylindrical conductor, or law of initial development of the current through different parts of its cross section.

12. Let *abd*, fig. 6, be the cross section of a cylindrical conductor of great length, and let a current be developed in it by the application of an electro-motive force acting uniformly through all parts of the cross section. Take any point *c* in the diameter *ad* (whose distance *fc* from the centre we will call z), and draw the chord *kcl*, making with *ad* any angle $acl = 90° + \varphi$. Draw the perpendicular *fg*, and in *kl* take any point *h* and draw the straight line *fh* producing it to *m* and *n* and denote *gh* by x and the angle *gfl* by φ'. Following the motion of the lines *fg* and *fl* as *kcl* makes its motion of 180°, this angle φ' is to be taken greater or less than 90° according as φ is greater or less than 90°. Putting R for the radius of the circle, we shall have kg or $gl = R \sin \varphi'$. The rate of development $\frac{dQ}{dt}$ at the point *h* may be safely assumed to depend on the distance *fh* from the centre, which distance determines the value of the rectangle $mh \,.\, hn$ and consequently that of $kh \,.\, hl$ or $R^2 \sin^2 \varphi' - x^2$; $\frac{dQ}{dt}$ must therefore be some function of this latter quantity, or

6.



$$\frac{dQ}{dt} = F(R^2 \sin^2 \varphi' - x^2).$$

Substituting this value in formula (F′) and also that of $dr = dx$ and then replacing the limits of r by those of x, we have

$$(F'') \qquad \frac{dP}{ds} = \tfrac{1}{2} C \pi \int_0^{\pi} \left(\int_{-R \sin \varphi'}^{+R \sin \varphi'} F(R^2 \sin^2 \varphi' - x^2)\, dx \right) d\varphi.$$

Our problem requires that such a form be given to the function $F(R^2 \sin^2 \varphi' - x^2)$, which we may call simply F, that the second

member of the last equation shall be independent of z or of φ'. We shall first show that this requires that

$$\int_{-R\sin\varphi'}^{+R\sin\varphi'} F\,\mathrm{d}x$$

be also independent of z. It is obvious that the value of this integral is determined by that of $\sin\varphi'$,* so that

$$\int_{-R\sin\varphi'}^{+R\sin\varphi'} F\,\mathrm{d}x = f\sin\varphi'$$

which being substituted in (F″) we have

$$\int_{o}^{\pi} f\sin\varphi'\,\mathrm{d}\varphi$$

for the integral part whose variation consequent upon a change δz in the value of z must always be zero. Now we have, $\delta\varphi$ being $=0$, and $R\cos\varphi' = z\cos\varphi$,

$$\delta\int f\sin\varphi'\,\mathrm{d}\varphi = \int f'\sin\varphi'\;\delta\sin\varphi'\,\mathrm{d}\varphi$$

$$= -\frac{\delta z}{z}\int f'\sin\varphi'\,\frac{\cos^2\varphi'}{\sin\varphi'}\,\mathrm{d}\varphi,$$

where $f'\sin\varphi'$ is put for $\dfrac{\mathrm{d}f\sin\varphi'}{\mathrm{d}\sin\varphi'}$,

whence we must have

$$\int_{o}^{\pi} f'\sin\varphi'\,\frac{\cos^2\varphi'}{\sin\varphi'}\,\mathrm{d}\varphi = 0,$$

for all values of z from 0 to R. But it is obvious that $\dfrac{\cos^2\varphi'}{\sin\varphi'}$ is necessarily positive throughout the integration, and therefore in order that the complete integral may be zero, $f'\sin\varphi'$ must either be always zero or else must change its sign between the limits of integration, and that for all the values of z. Now this last is impossible, for whatever be the nature of the function, $f'\sin\varphi'$, its value and sign must be the same above the limit of $\varphi' = \frac{1}{2}\pi$ as below it,† and limits $\frac{1}{2}\pi - v$ and $\frac{1}{2}\pi + v$ can be assumed for the values of φ', within which the value of $f'\sin\varphi'$ being, if possible, greater than zero, does not change its sign. But the value of z can be taken so small as to bring the values of φ' within those limits throughout the whole integration. The

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* Not that this is necessarily true, but that it is so in the present case where the value of F is the same whether φ' be greater or less than $\frac{1}{2}\pi$.

† Not necessarily but because this is the case with the function $f\sin\phi'$.

value of the integral therefore cannot be zero for all values of z unless

$$f' \sin \varphi' = 0$$

and consequently

$$f \sin \varphi' = \int_{-R \sin \varphi'}^{+R \sin \varphi'} F \, \mathrm{d}x = \text{constant.}$$

Let now the function F be expressed as a series of powers of its root $R^2 \sin^2 \varphi' - x^2$, so that

$$F = L (R^2 \sin^2 \varphi' - x^2)^n + L' (R^2 \sin^2 \varphi' - x^2)^{n'} + \text{ \&c.}$$
$$= \Sigma \{ L (R^2 \sin^2 \varphi' - x^2)^n \}$$

Then putting $x = u R \sin \varphi'$, we shall have

$$\int_{-R \sin \varphi'}^{+R \sin \varphi'} F \, \mathrm{d}x = \Sigma \left\{ L (R \sin \varphi')^{2n+1} \int_{-1}^{+1} (1 - u^2)^n \mathrm{d}u \right\}$$

The second member of this equation expresses a series of powers of $R \sin \varphi'$, and this series cannot be constant or independent of φ', except for the single term in which the exponent of the power is $= 0$ or $n = -\frac{1}{2}$. The coëfficients of all the other powers must $= 0$, and this requires that $L = 0$ in those terms since $\int_{-1}^{+1} (1 - u^2)^n \mathrm{d}u$ is necessarily greater than zero for all values of n. This reduces the above value of F to

$$\text{(G)} \qquad F = L (R^2 \sin^2 \varphi' - x^2)^{-\frac{1}{2}} \text{ and}$$

$$\int_{-R \sin \varphi'}^{+R \sin \varphi'} F \, \mathrm{d}x = L \int_{-1}^{+1} \frac{\mathrm{d}u}{(1 - u^2)^{\frac{1}{2}}} = 2L \sin^{-1} 1 = L\pi.$$

Substituting this value in (F″) and putting $L = KR$ we have

$$\text{(F‴)} \qquad \frac{\mathrm{d}P}{\mathrm{d}s} = \tfrac{1}{2} CKR\pi^3.$$

13. If we now draw the chord *pho* perpendicular to *mn* we have $(R^2 \sin^2 \varphi' - x^2)^{\frac{1}{2}} = (kh \,.\, hl)^{\frac{1}{2}} = hp$ or ho, and consequently the value of $\dfrac{\mathrm{d}Q}{\mathrm{d}t}$ or F as given in G becomes

$$\frac{\mathrm{d}Q}{\mathrm{d}t} = K \frac{R}{ho}$$

where K is the value of $\dfrac{\mathrm{d}Q}{\mathrm{d}t}$ at the centre of the circle.

When, therefore, an electric current is generated in a long straight cylindrical wire, by an electro-motive force that acts uniformly throughout its mass, the rate of initial development of the

current through any fibre will be inversely as the length of the shortest chord that can be drawn in the cross section through that fibre.

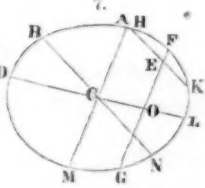
14. The equation (F'''') gives us the inductive force for any point within the wire. For a point exterior to it, the quantity φ' or z does indeed, in the process of integration, eliminate itself from $\int_{-R\sin\varphi'}^{+R\sin\varphi'} F\,dx$ in the same manner as before, but z now becomes an element of the limits of the second integration with reference to φ, or in other words, the interval between the lower and upper limits of φ is confined to the angle subtended by the cross section of the wire, and if this angle be denoted by β, the integration gives us for an exterior point

$$(F'''') \qquad \frac{dP}{ds} = \tfrac{1}{2} CKR\pi^2\beta,$$

which shows that for a current following the law of development just deduced, the exterior inductive force at different distances is directly as the angle subtended by the cross section of the wire. The inverse ratio of the distance from the centre would require it to be as the sine of half the subtended angle, so that in the very near vicinity of the wire the induction could not be estimated as if the current were all generated through the axis of the wire.

15. In a conducting wire having its cross section an ellipse, a law of development would obtain perfectly analogous to that of the cylindrical wire. Let ADG, fig. 7, represent the cross section and E any point in it. Draw the chord GEF making any angle φ with a given line, and let HEK be the chord which is bisected in E, and parallel to GEF and HEK draw the diameters ACM and BCN, and draw DCL bisecting GEF in O. Let $CA = r$, $OF = cr$ and $OE = x$. The properties of the ellipse give us

7.



$$\frac{HE^2}{BC^2} = \frac{GE \cdot EF}{AC^2} = \frac{c^2r^2 - x^2}{r^2}$$

If then the rate of development through E be always equal to

$$L\frac{BC}{HE} = L\left(\frac{c^2r^2 - x^2}{r^2}\right)^{-\frac{1}{2}}$$

and this be substituted in (F'), we shall have for the inductive force at any point within the section

$$\frac{dP}{ds} = \tfrac{1}{2} CL\pi \int_0^{\pi} r\left(\int_{-cr}^{+cr} (c^2r^2 - x^2)^{-\frac{1}{2}}\,dx\right) d\varphi = \tfrac{1}{2} CL\pi^2 \int_0^{\pi} r\,d\varphi,$$

that is

If a current be generated in a conducting wire whose cross section is an ellipse, in such manner that the rate of development through any fibre, shall be in the inverse ratio of the chord bisected by that fibre, and in the direct ratio of the diameter to which that chord is parallel, the inductive force will be the same in all parts of the cross section.

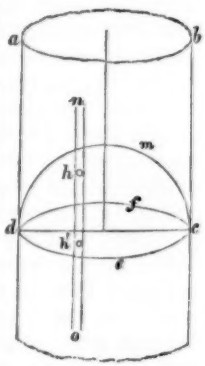
16. These results, if the fundamental law of induction as laid down be really true, leave no doubt that the initial development of a current in an extended wire, is more rapid at and near the surface of the wire than at the centre, and that in round wire it follows the law indicated in 13. In the case of a galvanic current, the resistance to conduction would come in as an element and interfere with this law as the quantity of current increases, until finally the electro-motive force comes into equilibrium with the resistance to conduction, when the current becomes uniform in quantity throughout the mass of the wire. But in discharges of common electricity, and in the slight currents that take place in electric waves of moderate length, there is strong reason to believe that the resistance to conduction is in most cases trifling compared with the inductive force, because the charge is exhausted before the current has had time to reach more than a very small fractional part of the quantity that would be maintained by the electro-motive force applied. In the discharge of a Leyden jar through a wire, the quantity of electric fluid passed is almost infinitesimal compared with that of a galvanic current excited even by a very small galvanic battery, in a moment of time, while the electro-motive force due to the intensity of the charge is beyond comparison, greater than that of our most powerful voltaic combinations, and could this immense force be continued till the resulting current had made any thing like an approach to its maximum quantity, the wire would be almost instantly dissipated, perhaps with explosions, unless that maximum were reached and passed in a space of time inconceivably minute. It is highly probable that future investigations will show that this latter alternative must in most cases be rejected. Some unpublished experiments of Prof. Page which I had the pleasure of witnessing, made with very heavy coils of wire, showed in that case a very sensible and even measurable space of time, to be necessary for the complete development of the current by the force of a galvanic battery, and this time should be the same in the same conductor for any other electro-motive force however great. The complete settlement of this question of the time required for the current to reach its maximum, or of the rate at which it will approach it in a given conductor, depends on the experimental determination of our constant C. On the strength of these considerations, I propose further on to develop the laws of electric discharges

through metallic wires, on the presumption that the resistance to conduction is slight compared with the electro-motive and inductive forces concerned, it being understood however, that they are offered only as conclusions to be hereafter submitted to the test of experiment.

17. In discharging a Leyden jar through a wire, the current once generated by which the discharge is effected, is not to be checked except by the exertion of a similar amount of electro-motive force in the contrary direction to counterbalance or neutralize the induction at the cessation or falling of the current. Hence the current rushes on as if it had momentum, until it charges the coatings of the jar oppositely to their original charge, when a second discharge in the opposite direction to the first commences, and thus a series of vibrations ensues, as first suggested by Prof. Henry, which ought to be perpetual if they were not gradually reduced by the resistance of the wire and of the space in which the spark occurs. The latter resistance is probably small after the air is once penetrated and so continues, we may reasonably believe, as long as the vibrations last. These conditions are absolutely essential to the existence of this succession of vibrations, and therefore receive strong support from numerous unpublished experiments of Prof. Henry, in which he informs us he has shown the existence of these vibrations in the discharge of a jar.

18. It may not be uninteresting to trace some geometrical relations. In fig. 8, let *a b c d* be a portion of a conducting wire, of which *def* is a cross section, and on *def* imagine a hemisphere *dmc* to be erected, and let any longitudinal prismatic element or fibre *no* of the wire be cut by the hemispherical surface and by the cross section so as to form the sections *h* and *h'*, *h'* being in fact the projection of the small spherical surface *h* upon the plane *def*. Now if *h'* be constant, the area of *h* it will readily be seen is inversely proportional to the shortest chord that can be drawn in the circle *def* through *h'*. Hence the rate of development of the current conducted by the elementary prism *no* is proportional to the area of the section of the latter by the spherical surface inscribed in the wire. And what is thus affirmed of an elementary prism may obviously, by adding together many elementary prisms, be extended to any finite prism. The development of current in it in an electric discharge is measured by the area of the section of it by the spherical surface.

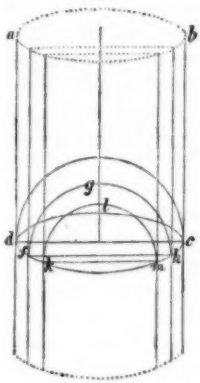
8.



19. In fig. 9, let the conductor *abcd* be cut longitudinally by two parallel planes whose intersections with the spherical surface form the zone *fghklm*. The area of this zone is simply proportional to the distance between the two planes, and therefore by what we have just seen, the same is true of the rate of development of current in the plate of metal included between the cutting planes, and the same relations will obviously exist with the quantity of current, at any given instant of time as with the rate of development.

20. From this it would appear that if an electric jar or battery were discharged through a cylindrical conductor composed of flat metallic plates of equal thickness, in the manner represented in fig. 10, each plate, whether the wide central ones or the narrower ones near the sides, would conduct the same part of the whole charge.

9.



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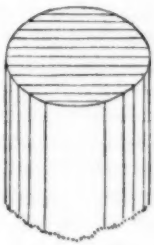

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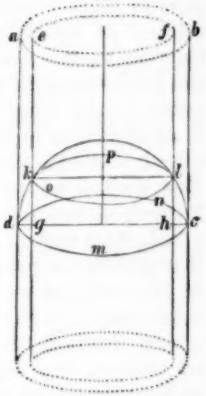

21. If we would estimate the comparative rate of initial development of a current in a thin shell *a b c d e g h f*, (fig. 11,) of a cylindrical conductor, we have only to consider the area of the spherical zone *d m n k o p* which it covers, and which area is proportional to the altitude *g k* of the zone. The thinner the shell the greater manifestly is the ratio of this altitude to the thickness of the shell, till at the extreme surface the ratio is infinite and the development instantaneous, so that the current would there begin from the first instant to feel the resistance to conduction. It is manifest however, from an inspection of the figure, that extreme rapidity of the initial development extends only to an extremely minute depth into the wire, and not far enough to make the effect of resistance there, affect sensibly the general character of the current in the case of those electric discharges which we are considering. Notwithstanding, then, the comparative quick-

ness with which resistance to conduction is felt at the surface, the quantity actually developed in proportion to the mass very near the surface, would be extremely great in comparison with the quantities developed at greater depths, and this tendency of the initial current to the surface does certainly offer some analogy to the accumulation of statical electricity at the surface, though with the difference that the great proportion of the current does, notwithstanding, take the interior of the conductor. One tenth only of the whole initial development belongs to the external shell equal in thickness to the two hundredth part of the radius, which would include a hundredth of the mass nearly.

22. But this thin shell would, nevertheless, conduct ten times its share of the current minus the allowance to be made for resistance to conduction, and we ought therefore, according to the foregoing conclusions and views of the character of the discharges of common electricity, to perceive the mechanical or heating effects of such discharges much sooner on the surface than in the interior of the wire. When, however, we consider the great thinness of the shell exposed to any great excess of current, and the readiness with which any heat generated would be conducted away by the metal within, it can hardly be considered a very serious objection to our conclusions if no instance has yet been adduced of a lightning rod or conducting wire, having its mere surface melted away, especially in the absence, so far as I am informed, of any experiments specially directed to that point.

23. As a test of the conclusions I have ventured to put forth, it might be proposed to coat a conducting wire with a thin sheet of the same, or a more refractory metal, separated from the main wire, except at the ends, by a bad conductor of heat, and to discharge through the whole a heavy electric battery. I have essayed such an experiment but find my small electrical machine and battery altogether insufficient to furnish the necessary quantity.

Law of conduction of a discharge of common electricity through a straight conducting wire.

24. If it be true, as we have supposed above, that the principal part of the resistance encountered by a discharge of common electricity through a wire, is due to the induction of the current upon itself, it is obvious that the law of conductibility of wires of different lengths for such discharges, is quite independent of their conductibilities for galvanic currents. In proceeding to deduce the law of conductibility or conducting power for electric discharges, so far as it has reference only to the induction of the current upon itself, it will be necessary to begin with a precise definition of conducting power. In galvanic electricity the conducting power of a wire may be said to be proportional to the quantity of statical electricity that can be propelled through it in a given time by a given electro-motive force after the cur-

rent has reached its maximum and become constant. This is the obvious definition, and we shall adopt a like one for the conducting power for a discharge of common electricity except that, in the time, we are confined to the minute space of time occupied by the discharge, and in which the current is supposed to make but a slight approach toward the maximum or constant state.

25. Let Q' represent the whole quantity of statical electricity, that passes through the wire during the time t elapsed after the instant when the electro-motive force begins to act. Then $\frac{dQ'}{dt}$ will represent the whole quantity of the *current* at the end of the time t, and $\frac{d^2Q'}{dt^2}$ will represent the rate of development of the current in the whole wire. Let K represent as before the value of $\frac{dQ}{dt}$ at the centre of the cross section *abd* fig. 6, of the wire. Then by the law above laid down, the value of $\frac{dQ}{dt}$ at any point in the circumference of any circle concentric with *abd*, and whose radius is r, will be

$$\frac{KR}{\sqrt{R^2-r^2}}$$

and this multiplied into the area of the elementary ring included between the limits of r and $r+dr$ will give

$$2\pi r\,dr\,\frac{KR}{\sqrt{R^2-r^2}}$$

for the rate at which the current is developed through the elementary ring; and the integral of this taken between the limits of $r=0$ and $r=R$ will give the rate of development of the whole current thus

$$\frac{d^2Q'}{dt^2}=2\pi KR\int_0^R \frac{r\,dr}{\sqrt{R^2-r^2}}=\pi KR^2$$

whence we have

$$K=\frac{d^2Q'}{dt^2}\,\frac{1}{2\pi R^2}.$$

If we now substitute this value of K in equation (F'''), then, still supposing the length of the wire to be great in comparison with its diameter so that the short spaces at the extremities in which there is any sensible change in the relations of the development of the current to the section of the wire and to the induc-

tion force may be neglected, equation (F''') will obviously give us for the induction throughout the whole length S of the wire

$$P=\tfrac{1}{2}CKRS\pi^2=\tfrac{1}{4}C\pi^2\frac{\mathrm{d}^2Q'}{\mathrm{d}t^2}\frac{S}{R}$$

(*a*) whence $$\frac{\mathrm{d}^2Q'}{\mathrm{d}t}=\frac{4}{C\pi^2}\frac{R}{S}P.$$

Here the whole inductive force P is, agreeably to the hypothesis we are now considering, the only resistance encountered by the current. It must therefore be equal to the electro-motive force that generates the current and we shall now call P the electro-motive force. If this be supposed constant during the time t, equation (*a*) gives us

(*b*) $$\frac{\mathrm{d}Q'}{\mathrm{d}t}=\frac{4}{C\pi^2}\frac{R}{S}Pt$$

and this gives

(*c*) $$Q'=\frac{2}{C\pi^2}\frac{R}{S}Pt^2$$

from which it appears that the quantity of statical electricity passed through the wire by a given electro-motive force in a given time, or the conducting power of the wire for an electric discharge, is proportional to its *diameter*, and inversely proportional to its length.* This differs essentially from the law of conduction for galvanic currents in that the conducting power is directly as the diameter, while in constant galvanic currents it is as the cross section or square of the diameter.

Again, equation (*c*) shows that the conducting power (measured by Q') and the resistance to discharge, (measured by P), may be considered as the reciprocals of each other, since any change of R or S that will increase Q' while P is constant, will diminish P in the same ratio when Q' is constant.

I have here considered P as constant during the time t, but this is not true in practice in an electric discharge, since the electromotive force due to the tension of the charge must diminish as the charge proceeds. Hence, although the above may be regarded as the expression of a law, still the only way in which we can practically bring the conductibility or resistance to discharge of two wires into strict comparison, is by passing a charge of machine electricity through the two simultaneously, either by dividing it between them, or joining them end to end and passing the whole charge through both.

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* It would be easy to show in a general way, that this law of electric discharge should apply to straight conductors having similar cross sections of any form, but I do not contemplate testing it with any other than round wire.

And first, if we divide the charge between the two wires, we must now integrate (a) considering P as a function of the time, and two successive integrations give us

$$\frac{\mathrm{d}Q'}{\mathrm{d}t}=\frac{4}{C\pi^2}\frac{R}{S}\int P\,\mathrm{d}t$$

and

$$Q'=\frac{4}{C\pi^2}\frac{R}{S}\iint P\,\mathrm{d}t^2.$$

Now as the discharge is divided between the wires, the electromotive force P at any given instant, is the same obviously in both wires and consequently $\iint P\,\mathrm{d}t^2$ is the same in both, and the quantity of statical electricity Q' discharged by each is consequently as its diameter and inversely as its length.

Secondly, if we pass the whole charge through both wires joined end to end, the quantity Q' that shall have passed at any given instant must be the same in both, and consequently also the value of $\frac{\mathrm{d}^2Q'}{\mathrm{d}t^2}$. Hence equation ($a$) shows that

$$\frac{R}{S}P$$

must have the same value in both wires, so that P the resistance to discharge, is inversely as the diameter of the wire and directly as its length.

In all the foregoing investigations relating to the discharge of accumulated statical electricity, although the length of the wire has been supposed great, in comparison with its diameter, yet we have proceeded on the tacit supposition, that its surface is not sufficient to absorb any sensible part of the charge to be passed through it. But if the wire be of such length as to give it an extensive surface capable of itself receiving or absorbing the charge, the current of discharge will be no longer simultaneous through the whole length of the wire, and the phenomenon of electrical waves will come in, which is probably nothing more than the successive charging or discharging of the surface of the wire.

Washington, D. C., August, 1850.

Art. III.—*On Meteorites;* by Charles Upham Shepard.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

1. *Tuttehpore, Hindostan, Nov.* 30, 1822.

This stone, so far as I am informed, has not been described. It is barely mentioned by Prof. Partsch, in the appendix, p. 142, of his Catalogue of Meteorites in the Imperial collection at Vienna, (1843) as not yet brought into Europe. While in Edinburgh last year, I was informed by Alexander Rose, Esq., that a fine specimen of this locality existed in the cabinet of Thomas McPherson Grant, Esq., by whom I was very obligingly presented with a fragment, and the means of making the present communication.

The fall took place in the evening at Tuttehpore, which is situated seventy-two miles from Allahabad on the Cawnpore road, in lat. 25° 57′ N., and long. 80° 50′ E. The meteor from which the stone was ejected, was of large size, surpassing the full moon in apparent magnitude as well as splendor. It passed from southeast to northwest. A number of stones fell, the largest of which weighed 22 lbs., but that in the possession of Mr. Grant was the only one in an entire state, which was found. It was brought from India by Dr. Tytler, by whom it was presented to its present owner.

The stone is oval, slightly compressed, indented, and possesses a brownish black crust. Its weight is about two pounds. It is fine grained, trachytic and resembles most closely the stones of Poltawa (March 12, 1811), and of Castine (May 20, 1848.) Sp. gr. =3·352.

2. *Charwallas,* 30 *miles from Hissar, India, June* 12*th,* 1834.

This is another stone of which the only notice I have met with is found in the Appendix of the above mentioned work, (p. 143),—Prof. Partsch remarking that no portion of the mass had made its way into Europe. The entire stone is in the possession of Prof. Jameson, to whom it had been presented by a relative resident in India at the time of its fall. Its exact weight I am not able to give; but I have the impression that it cannot fall short of 7 or 8 lbs. I owe a fine slice of several ounces weight to the kindness of Prof. Jameson, from an examination of which, I am able to give the following description.

It is one of the toughest stones, if we except those of Chantonnay (Aug. 5, 1812) and Cabbarras Co., N. C., (Oct. 31, 1849), with which I am acquainted. It is filled with iron rust, like certain weathered, fine grained granites, in consequence of which, and the smallness of the particles of composition, it is impossible to recognize the mineral species, (with the exception of the nickeliferous iron) of which it is made up, although olivinoid, and one of the feldspar species, appear to be the leading ingredients.

On exposure to the air, it deliquesces, yielding chlorid of iron; but this does not prove chlorine to have been an original ingredient of the stone, since the mass, as in the case of one of the Iowa (Feb. 25, 1847) stones, may have been since its fall in some situation where chlorine has been imparted to it.

Its specific gravity is 3·38. It contains 15·07 per cent. of nickeliferous iron, with traces of sulphur. The stoney part consists of silica, magnesia, protoxyd of iron, alumina and lime.

3. *Meteoric Iron, County Down, Ireland. Fell August* 10, 5 P. M., 1846.

For a knowledge of this meteorite I am indebted to my friend Dr. John Scouler, Prof. of the Royal Dublin Institution, who wrote me as follows respecting its fall, in February, 1848. "I believe I must give you the credit of having discovered another meteorite in Ireland, or in other words, but for you I would not have been at the pains of finding it out. The stone or stones fell in 1844, in the north of the county of Down, and were seen to fall by some of the coast guard. You will find two small specimens of this stone along with the other specimens in the box." Owing to an accident in the transmission of the box, the specimens were not received until within a few months, and hence the delay in making known this interesting fall of meteoric iron. The only additional information concerning the event, which I am at present able to communicate, is the circumstance mentioned in the label accompanying the specimens, "that the name of the man who saw the mass fall and who picked it up, was Gibbon."

The following is all that I am able at present to make known concerning the mass. It is malleable, homogeneous, and amygdaloidal. Specific gravity variable: vesicular portions = 5·9. Crust thick, sometimes one-third of an inch and consists of mixed oxyds of iron, somewhat coated by blue phosphate of iron, (vivianite.) In moist air, the chlorid of iron deliquesces in little drops. It does not afford the Widmanstättian figures. It does not contain nickel, cobalt, or sulphur.

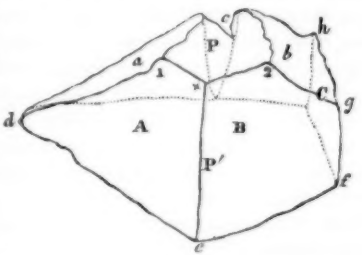
4. *Description of a large stone of the Linn Co., Iowa, fall of Feb. 25, 1847.*

This stone, weighing twenty pounds, has lately come into my hands through the agency of Rev. R. Gaylord, of Hartford, Iowa, the same gentleman who procured for me the specimens which were picked up at the time of the explosion of the meteor, and of which an account was given at a former meeting of the Association, (see vol. iv, 288, 289, of this Journal.)

The following statement respecting it is from the Rev. Mr. Gaylord's letter of July 3d, 1850. "It was found (in the summer of 1847) in Hooshier grove by Abner Cox. He was in company with John Hollis, of whom I obtained two fragments three years ago. They have had the stone two years or more, and by lying in the loft of a smoky cabin, it is somewhat dingy in appearance. This John Hollis is the man who ground up so much of the stones that were seen to fall, in order to get silver. He was the means, however, of the careful preservation of the present mass. Dr. Knight found they had the stone, and wrote me respecting it.

"The three pieces into which it broke on striking the ground fit together exactly, so as to reproduce the original stone, with a complete coating over the whole, except on one side where several small fragments were broken out by the fall. These were gathered up carefully and preserved by the finder."

This stone is perhaps the most remarkable one thus far described, for its highly regular prismatic figure, which at once suggests the idea of a portion of a basaltic column. Nor can the geologist look upon it without feeling almost certain, that it once formed part of some extensive formation in the world from whence it came.



Its dimensions will be best understood from an examination of the annexed figure. P and P′ are the bases, A B and C the vertical sides of the prism: 1 and 2 constitute the less regular 4th and 5th faces of the figure. *c* denotes a portion of the stone which is wanting. *a* and *b* are sloping sides, *a* inclining to P under an angle of about 130°, and the diagonal of *b* to the line *g f*, under 100°. The surfaces P and P′ are nearly flat, and agree in presenting a peculiar wavy, undulating surface and a deeper black color than belong to the other faces of the stone, a difference which appears to originate

in the nature of the horizontal cleavage of the mass as contrasted with that which is vertical or oblique.

The greatest diameter of the base P′ is $10\frac{1}{4}$ inches.

From	*e* to *f*	measures	$6\frac{1}{2}$	inches.
"	*e* to *d*	"	7	"
"	*e* to *x*	"	$5\frac{3}{4}$	"
"	*g* to *f*	"	$3\frac{3}{4}$	"
"	*g* to *h*	"	$3\frac{3}{4}$	"
"	*x* to 2	"	$2\frac{1}{4}$	"
"	*b* to *g*	"	$4\frac{1}{2}$	"

The fragments which came from the chink *c* are rich in chlorine, deliquescing freely with chlorid of iron when exposed to a moist state of the air; while the rest of the stone is quite free from this constituent, and precisely resembles the other stones of the locality already described. This difference of composition in one and the same stone is probably owing to the fact, that the fragments in question must have remained for a considerable time partially buried in the soil and have imbibed the chlorine from thence; while the main mass being above ground and more protected by its coating was preserved from such an impregnation.

5. *Meteoric Stone of Waterloo, Seneca Co., N. Y.; fell in the summer of* 1826 *or* 1827.

For my first knowledge of this remarkable stone, I am indebted to Prof. O. Root, of Hamilton College, from whose letter dated Clinton, N. Y., Jan. 26, 1850, the following abstracts are made. "On receiving your note, I wrote to my friends in Geneva, for the meteorite mentioned in my letter to President Hitchcock. Judge Watkins very willingly gave the specimen, and it is now in my possession, subject to your order. The piece is not large (it weighs about 1000 grs.,) as the original mass had been divided two or three times. Not being familiar with such productions my opinion concerning its genuineness is of no value. Judge Watkins, however, is a gentleman of high respectability, and I have confidence in what he relates of the history of this stone. My attention was directed to the subject in the following manner. A year or two ago, while showing some gentlemen a fragment of the Otsego meteoric iron, one of them observed that he remembered a report many years back of a stone falling through a roof in Waterloo, or in that vicinity. After many inquiries, I at last found the stone or a fragment of it, with Judge Watkins. He relates that a hole was discovered in the roof of his mill directly over a bin of wheat,—that the opening was made through the shingles where the roof-boards were about five inches apart (although a piece was split from the roof-board on one side),

and that under the hole there appeared a depression in the grain, which led to an examination that resulted in the discovery of the stones. The Judge inferred that the stone had fallen through the roof, as its size was too great to have allowed its admission into the bin along with the grain, which was raised by means of elevators. He also supposed it to have been of atmospheric origin, as the mill was four stories high, and as the nature of the stone was unlike any of the mineral productions of the region, the rock in place at Waterloo, being the Seneca limestone. He was not positive whether it was found in 1826 or 1827. The stone was divided for Dr. Hale, President of Geneva College."*

The specimen presented me by Prof. Root, had been left for upwards of twenty years in the garret of Judge Watkins, where it appears to have been mistaken for something edible by the rats, who have left numerous markings of their incisor teeth upon its surface. Indeed, in color and texture, it nearly resembles common rhubarb. Its color is light buff or yellow. It is slightly coherent, and may easily be crushed between the fingers. Its sp. gr. =2·30. But a small portion of the original crust remains, which is reddish brown. The stone contains in small quantity, blackish particles attracted by the magnet. A surface produced by being cut with a saw, shows waved parallel lines of greater hardness than the rest of the stone. It consists of

Silica, ...	78·80
Peroxyd of iron, ...	8·72
Alumina, ...	6·28
Moisture, ...	4·75
	98·55
Lime and magnesia (in equal quantities) and loss,	1·45
	100·00

6. *Specific gravities of two meteoric irons.*

Meteoric iron of Pittsburg, Pa., . .	7·380
Meteoric iron of Salt River, Ky., . .	6·835

* I addressed a letter of inquiry to Dr. H., who informs me that the specimen has for some time been lost sight of in the college collection.

ART. IV.—*An Essay on the Classification of Nemertes and Planariæ: Preceded by some general considerations on the primary Divisions of the Animal Kingdom;* by CHARLES GIRARD.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

I.

I AM gathering materials for a monograph of the Nemertes of this side of the Atlantic. I have already said on another occasion that I was doing the same with regard to the Planariæ. It will not be anticipating the final results of these investigations to present here some general considerations respecting the place that may conveniently be assigned to these animals in our zoological system.

The chronological history and the position that the various authors have assigned to the Nemertes and Planariæ having been fully brought out by Mr. de Quatrefages,* I shall not dwell upon that part of the subject.

The question now under consideration bearing merely upon the fundamental groups of the animal kingdom, I need only go back to Cuvier, since he established these groups and since the foundations of our classification are the results of his labors.

Nor shall I at present enter upon the secondary divisions to be established among the Nemertes and Planariæ; this aspect of the question cannot be settled until we are better acquainted with the organization of the group of Rhabdocœla or freshwater Planariæ.

II.

Before however I treat of the Nemertes and of the Planariæ in a more particular manner, I have a few words to say on the subordination of characters in the primary groups of the animal kingdom.

There are in the animal kingdom but two main systems of organs to which all the others are related, being in a word, mere dependences or branches of them. These two systems of organs are: 1. the *nutritive system* or *system of vegetative life*, and 2. the *sensitive system* or *system of animal life.*

Now which of these two systems of organs is the most important; in other words, which ranks highest as a zoological character. The nervous system, some physiologists will answer. But let us examine this point. What is the distinguishing character of the animal kingdom as a kingdom? A digestive cavity of some kind, into which are introduced nutrient substances neces-

* Ann. Sc. Nat., 3d Série, iv, 1845, p. 129.

sary for the maintenance of living bodies; necessary to their growth anterior to the period of full development and to their equilibrium after having reached their complete size. The digestive system then is the universal character, common to all animals, and this character gives us the animal kingdom: it ranks then highest.

Next to the entire animal kingdom we have the four great primary divisions, the division of Vertebrata, the division of Articulata, the division of Mollusca and the division of Radiata, and these four divisions are characterized by the nervous system chiefly. The plan of structure of the nervous or sensitive system giving these divisions and these divisions exclusively, its importance is of a secondary degree. For the nervous system has not yet been materially demonstrated in all the Radiata, whilst the nutritive system is to be seen everywhere. Not that I deny the sensitive system to any animal even where it has not been shown. There exists among the lower Radiata a homogeneity of substance which is perhaps the only obstacle to its discernment; nevertheless the digestive system being everywhere distinct, this latter must have the preëminence.

It has the preëminence because it gives us the unity of the kingdom as we have also this unity in the perfect resemblance of all eggs at an early period of their history. In the animal the first substance which is formed is the vitellus or yolk; it is the foundation of the future being, it is, as Prof. Agassiz has observed, the being itself. Out of the yolk the nervous system originates as well as all other parts of the organism, so that in an embryological point of view the nervous system holds a second rank.

It is of secondary rank as a material organ and character of classification of animals. It plays the highest part by its immaterial essence in the human species. But here we leave the boundary of the animal kingdom and therefore the classification, which is our object, to enter another kingdom, the kingdom of Thought.

The nutritive system being the index of animality we see all animals equally compelled to take food; this is the essential condition of their existence.

The nervous system being the fundamental basis of the primary divisions, it gives to each division a special immaterial tendency so long taught by Prof. Agassiz. Now as there are four divisions there are also four of these tendencies. And as soon as there are four immaterial tendencies, there is an antagonism amongst them. This is a natural consequence since the nervous system overrules the division and its dominion is of a spiritual character.

The nervous system stamps upon the divisions their zoological form as the symbol of their diverse tendency. We shall see

further an *apparent* anomaly of this kind in the beings placed at the boundaries of two divisions where the material form, to use the words of Milne Edwards, escapes the supremacy of the nervous system. The principle however remains always the remote cause.

Besides the antagonism of the divisions between themselves, there is an antagonism between the instinct and the intellect, that is to say, three of the divisions against the fourth: the Articulata, the Mollusca and the Radiata, collectively known under the appellation of invertebrate animals, all of which have only instincts, against the Vertebrata which possess, beside instincts, intelligence to a certain degree.

Now between the invertebrate animals and the vertebrata the struggle is latent, passive, because the two principles, the instinct and the intellect, do not coexist. But among Vertebrata where we find both the instincts and the intellect in the same individual, the struggle is active and direct, and we are indebted to the observations of Fred. Cuvier, for the revelation of this astonishing law, that wherever the instincts command, the intellect is actionless, and wherever the intellect governs, the instincts are silenced or nearly so. There is a struggle and an open struggle; the victory of one of the principles involves the subjection of the other.

Morally speaking, we might thus establish two series in the animal kingdom; an instinctive series, stationary and sightless, and an intellectual series, progressive and seeing; the first including three divisions, (Radiata, Mollusca, Articulata,) and the second only one (Vertebrata).

And now, if we go back to the origin of the animal kingdom, and trace its history in the past, we see the two series appearing simultaneously from the first manifestation of life upon the surface of the earth: the instinctive series with its three divisions and all the classes; while the intellectual series is represented by one class only, that of fishes.

Their forms are renewed during a succession of periods and each great revolution of the globe adds one class to the division of Vertebrata or the intellectual series, in the order of their zoological gradation: Reptiles, Birds and Mammals:—then Man crowning the whole work. Thus a real progress is manifested in the division of Vertebrata while the Invertebrate animals remain what they were, although undergoing a renewal of forms. The reason of this is, as Fred. Cuvier states, that the instinct is innate, always sightless, necessary and unchangeable, whilst the intellect is progressive, conditional and susceptible of modifications.*

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* Flourens. Resumé des travaux de F. Cuvier, sur l'instinct et l'intelligence des animaux. Paris, 1844.

In the intellectual series there was an aim, a design, and this was, to arrive at man, the true domain of intelligence. This aim realized, the creation would stop and it did stop. Zoological forms had acquired all that diversity with which the sphere of activity of each division was endowed. To the immaterial principles nothing was left except a limited play, a contest for supremacy. To intelligence alone was given the power to arrive at the knowledge of the actual world, to look back in time, to contemplate itself in the past in view of the future, finally to study itself,—in a word, to *reflect.**

The power of reflection belongs exclusively to man, the last being created. Man being the converging point of the material creation, in him were also to be concentrated in our time the struggles of the two spiritual principles of all past time.

One word more on the intellectual series. The fishes, reptiles, birds and mammals belong to this series, but the fishes, the reptiles, the birds and most of the mammals in their natural condition of life have no intelligence,—have no intellect.

The intellect resides within the brain, and the vertebrata alone have a true brain. The brain is composed of several parts. There is the base of the brain which sends nerves to the organs of sense, and the hemispheres, the special seat of the intellect. Now of the hemispheres the fishes have only a rudiment, and this is the reason why they have no intellect. There exists a well defined progression from the fishes to the mammals with respect to the development of the hemispheres; placed anteriorly in the fishes, they rise degree by degree in the other classes over the base which is gradually covered and concealed under them. Here we see the organ reflected upon itself, reminding us of its function in its full activity, reflection. To this gradual development corresponds a position of the head more and more raised which becomes vertical in man,—where it forms a right angle with that of fishes. One step more would have been retrograde: the development there stopped.

Thus by a gradation almost imperceptible we have beings belonging to the intellectual series which have the intellect only in a virtual state. They have the organ without having the principle, or at least admitting the principle virtually present, the organ is not sufficiently developed to allow its manifestation.

These general considerations, although a brief résumé, will perhaps appear out of place in this paper; but my object is the discussion of the value of the nervous system as a zoological character, and to show that while this system of organs gives only the divisions, these latter are governed by it in an absolute manner.

I now come to the special topic of my communication.

* Flourens. Resumé des travaux de F. Cuvier, sur l'instinct et l'intelligence des animaux. Paris, 1844.

III.

The place assigned by Cuvier to the Nemertes and to the Planariæ in his "Animal Kingdom," is entirely provisional as acknowledged by the illustrious naturalist himself.

The Nemertes are placed in the division of Radiata immediately after the *Intestina cavitaria*.

Between Nemertes and the intestinal worms of this order there are only analogies. The extraordinary length of the body of some of them, for instance *N. Borlasii* (Borlasia angliæ), a length reminding us of the class of worms, and above all of some of the intestinals, such as the tape worm, had prevailed over all other considerations. Their affinities were not acknowledged because their organization was unknown.

At that time the intestinal worms were regarded as Radiata, for the reason that their nervous system had not been found, and the Nemertes, as well as Planariæ, were regarded as intestinal worms because all of them reminded us by their forms, of the forms of these last.

When the more recent labors of some zoologists had established beyond any doubt that the intestinal worms belonged to the division of Articulata, on account, first, of their having a nervous system, and a nervous system constructed on the plan of that group, secondly, by the structure of their body, which is composed of a series of articulations or rings movable upon each other, then the Nemertes were carried with the *Intestina cavitaria* into the division of Articulata where they remained as little known as before. It is but of late that they have been made the subject of a special study by a skillful zoologist, Mr. de Quatrefages, and I am surprised that this author has not pointed out the close affinities which they bear to Mollusca.

Cuvier was well aware of the space which separated Nemertes from intestinal worms, inasmuch as he foretold that they would one day constitute a new order. In spite of these external resemblances, their structure which as he says "*is of an extreme softness*," caused him to doubt. Nevertheless it did not, on this account, enter into his mind to compare them with Molluscs.

At that time, as indeed now, the idea of a mollusc corresponded with the idea of a shell-bearing animal, with the form of a body more or less drawn together into itself, while the lengthening of the body involved by analogy the idea of a worm.

Now if abstracting the form, which is not the characteristic of the divisions, we look at the intimate structure, if we give up also the shell as circumscribing the division of Mollusca, we shall find in the Nemertes all the principal characters of Molluscs: a soft body, entirely smooth, covered with a glutinous mucosity; a very simple nervous system reduced to a small number of cephalic

ganglia, whence nervous threads depart to distribute themselves in the body. If we further state that, as in the greater number of Molluscs, the surface of the body is covered with vibratory ciliæ which help their movements, movements generally slow, deprived of energy, then we directly arrive at the idea that Nemertes are really Molluscs,—Molluscs of a low rank, being parallel with the worms of the division of Articulata by the analogy of their forms.

Having discussed above the value of the nervous system as the predominant character of the *division*, exclusively of any other character, it remains only for me to state that the nervous system of Nemertes is constructed upon the plan of the nervous system of Molluscs: there exists a cephalic mass more or less lobed, representing either the superior æsophageal ganglion of other Molluscs, or that same ganglion to which, on account of the peculiar form of the body, are added the two or three abdominal ganglia. Nervous threads are distributed in all directions; two of them more voluminous than the rest, but uniform in structure, run along the sides of the animal, and sending off thinner threads without showing in their course those ganglia or swellings which distinguish the nervous system of Articulata, such as it is in Malacobdella, Peripates, &c.

The disposition of the nervous system of Nemertes, then, is merely *analogous* to that of Annelids; its structure is that of the nervous system of Molluscs.

IV.

The position of Planariæ in the division of Radiata is not less curious than that of Nemertes. Included in the second order of intestinal worms, the *Parenchymata*, they are brought near the Trematodes, to which they have only analogies, in the same sense as those that Nemertes have to the *Intestina cavitaria*.

The *Intestina parenchymata* have been withdrawn from the division of Radiata and brought into that of Articulata, and for the same reasons as that of the *cavitaria*. The Planariæ, of course, have thus been compelled to follow them in the same manner as Nemertes have followed the latter. But also little investigated at that time, their affinities with Molluscs have escaped the eyes of zoologists.

The Planariæ are not parasitical as Trematodes are, and it is important that this fact should be noted, parasitism existing most extensively among Articulata. The investigations of Mr. de Quatrefages and others have moreover made us acquainted with their structure which, although not yet entirely understood, as I believe, is however of the highest interest. Indeed in Distoma the digestive system is constructed upon an analogous plan with that of Planaria; but the digestive system, as we have said, can-

not characterize the primary *division*. It gives but the subordinate groupings.

As soon as it is acknowledged that the *division* rests upon the structure of the nervous system, the fact that the nervous system of Distoma is that of Articulata, and the nervous system of Planariæ is that of Mollusca, there is no ground for further hesitation.

In Distoma there are two cephalic ganglia, whence nervous threads part for the anterior region of the body. From each one of these ganglia arises a nervous thread which takes its course backwards; this thread presents on its length a series of small ganglia, scarcely distinguishable upon the middle region, it is true; but very apparent towards the posterior region, where they are seen sending off smaller threads distributing them to the body. This arrangement of the nervous system of Distoma becomes especially distinct in Malacobdella where the same arrangement is found, with the ganglia of the lateral threads more developed. Thus, taking the nervous system into consideration, Malacobdella is one degree higher than Distoma, then Clepsine would follow in which the two threads are brought so close together that they combine into one single thread. Above Clepsine would rank the other Hirudines.

In Planariæ we have a cephalic ganglion more or less lobed on its circumference which sends nervous threads to all the regions. There are two more voluminous lateral ones (one on each side of the body) as in Distoma, but uniform as in Nemertes, still recalling here by analogy the nervous system of Articulata. The fundamental difference, although lest apparent at first sight, consists in the absence of ganglia upon their lengths, and this fact decides all.

The body of Distoma, indeed, is not articulated and this may perhaps lead to a belief of a closer affinity between Planariæ and worms. Their broad and flattened form would be better adapted to their mode of life without that structure. Moreover the articulation of the body, although a character of the division, is subordinate to the nervous system. Consequently there is no ground for surprise at seeing it vanish or even entirely disappear in those groups placed at the boundaries of two divisions as a material property in litigation, disputed by antipathic vital tendencies, each endeavoring to appropriate it to itself.

Considering now the softness of Planariæ, that glutinous mucosity which surrounds them, that body of a uniform shape without articulations and deprived of articulated limbs, that general apathy, all these are so many characters which they partake with Mollusca and do not partake with Articulata.

However, I do not know that any one has proposed to consider these animals Molluscs, although Baer and Dugès had already compared the inferior disk of Planariæ to the foot of Gas-

teropoda without thinking of bringing them together in the same natural group. Mr. de Quatrefages refutes this comparison. We shall come to it again presently.

For, if the shell does not characterize Mollusca, inasmuch as all living Cephalopoda are naked, and among Gasteropoda we have the whole group of Nudibranchiata deprived of a shell, that of Pteropoda, and among Acephala that of Tunicata, it requires no effort of imagination to admit in that division, animals such as Planariæ. They are flattened Molluscs in the same manner as Nemertes, are elongated or stretched Molluscs, as are also Dentalium, which nobody would place elsewhere than among Molluscs.

Many authors have spoken of the organization of Planariæ, from Dugès to MM. de Quatrefages and Blanchard. All have viewed them as worms, doubtless prepossessed by the idea that Cuvier who had established the divisions could not have been mistaken so far as to place side by side in the same order animals belonging to two different divisions.

But this error of the author of the "Animal Kingdom" is easily accounted for. At that time he was in want of the essential datum to settle such a question in its details, the knowledge of the nervous system.

The plan of structure of the nervous system, we have already said, and we cannot repeat it too often, gives only the division and nothing but the division. Now Cuvier did not know it when he laid the foundation of his classification; although he foresaw the four plans of organization of the whole kingdom; and as he said there are but four of these plans.

He who has done most after Cuvier to establish the doctrine of these four plans of organization, is Prof. Agassiz. He has the unquestionable merit of having followed out the traces of these plans beyond the existing creation, and in ascending through past ages of the world's history he has been enabled to reconstruct the biological phases to which I have alluded above. In reading the history of the earth on the strata which compose its crust as so many pages of a book written by the hand of the Creator, we then find again the thought of these four plans of organization preconceived by Cuvier, demonstrated as a doctrine by Prof. Agassiz.

These four plans of organization would acquire a far greater importance if embryology should ratify them. Now embryology does so. All embryological investigations past and contemporaneous lead towards four plans of structure. I shall not treat of this question more in detail here; it is sufficient merely to mention the fact.

* * * * * * *

Now the question respecting the class among Molluscs to which Planariæ belong is easily settled. They crawl on the inferior

surface of their body; that they are Gasteropods, there can be no doubt. Do we not see them, as well as Pulmonata, Nudibranchiata and others, creeping along the walls of a basin and when near the surface of the water, reversing their position and walking in that manner with the same facility? Do we not witness the same undulatory contractions in that foot? Therefore were not Baer and Dugès guided aright when they compared the inferior surface of the body of Planariæ to the foot of Gasteropods?

I am not aware that any of the Planariæ I have studied moves with the same facility on the back as on the belly as Mr. de Quatrefages states. Whenever I placed them in that position I always saw them changing it as quickly as possible. Besides in most cases I have seen the upper surface differing widely from the inferior one.

In Planocera we have on the dorsal surface two cylindric tentacles, analogous to the cephalic tentacles of Doridians. In Thyzanozoon or Eolidicera, the cephalic tentacles are flattened and are brought entirely forwards while other tentacles appear on the back, reminding us of the dorsal appendages of Eolidians proper. Then come Proceros and Procerodes with but the flattened anterior tentacles of Eolidicera and in the same place as in these last.

There exist then in the marine Planariæ one group which reminds us of Doris, another of Eolis, and still another group intermediate between Eolis and Planaria proper which lead to the freshwater species.

This shows that it is near Nudibranchiata that Planariæ will find a natural place, and on several accounts we should be tempted to consider them as a degradation of that type.

But for us who do not admit the so-called degradations, inasmuch as each being appears to us as to Cuvier, *a perfect whole by itself*, we consider Planariæ as a family nearly allied to that of Nudibranchiata, bearing in itself the reason of its existence as strongly defined as this latter, and representing merely a variation in the thought of the Creator.

For, in Nudibranchiata we find a number of types all as much diversified. These are: *Doridians*, *Eolidians*, then *Canthopsis* analogous to *Procerodes* which leads to the *Acteonians*, then finally the genera *Pelta* and *Chalidis* which constitute another group almost Planarian, deprived of external appendages of any kind.

There exists a striking parallelism between the zoological forms of these two families.

Viewed in the light of their organization nothing is more alike. The nervous and digestive systems scarcely differ. I have already spoken of the first. With regard to the second I shall recall the fact that it is ramified in Nudibranchiata as in Planariæ; the ramifications being diversified according to the groups.

The organs of generation do not differ much more. Nudibranchiata are androgynous like Planariæ. The fecundation takes place by mutual fecundation as is the case in Pulmonata. But in Planariæ we have cases where an individual fecundates itself, the hermaphroditism being here complete.

V.

It still remains for me to make some general remarks upon Nemertes and Planariæ.

Mr. de Quatrefages tells us himself, "neither Nemertes nor Planariæ have externally a resistant and tough layer, similar to that which is found with Annelids, for example, or even with Rotatoria."*

We have then two groups of Gasteropodous molluscs parallel with two groups of annulated Articulata; the group of Planariæ reminding us of Helminthes, and the group of Nemertes reminding us of the Hirudines.

At the extremes of these two groups, at the bottom of the two classes, we witness in some sort a strange and opposed struggle of the two immaterial principles of the divisions which exert themselves to take from each other some portion of their material property. As examples we have:

In Molluscs,—the Nemertes which elongate and become worm-like; the Planariæ which remain shorter but pressed down, spread out, flattened in thin leaves.

In Articulata,—the softness of Helminthes in general, the flattening of their body in Trematodes in which the articulation of the body vanishes, analogous to Planariæ;—the softness still of the Leeches with a distinct articulated structure, being parallel with Nemertes.

These groups do not oppose each other in an exact parallelism, for Nemertes which form a low type of Gasteropods are opposed to the Leeches of a higher grade of worms, and Planariæ a higher grade among Gasteropods are opposed to Trematodes a lower type among worms. In this manner:

In the elongation of the body of Nemertes there is nothing to surprise us. Placed at the bottom of the class to which they belong, they assume a form analogous to a group of the division of Articulata which attract them but to which they do not belong. Now when a Mollusc, whose body is elongated beyond all pro-

* Ann. Sc. Nat., 3d series, vol. iv, 1845.

portion, and obliged sometimes to move by the contraction of transverse muscular fibres, accelerates its progress, then we see that Mollusc assuming certain transverse, irregular and unequal folds,—shadows of articulations which in reality do not exist.

At the bottom of the division of Articulata we observe similar facts. The Trematodes lose insensibly that elongated form of the body which constitutes the prominent character of the worms; they are flattened, spread out, meanwhile the articulation of the body, the characteristic of their type, vanishes completely,—thus foreshadowing the type of Planariæ.

The position and number of eye-specks in Nemertes and Planariæ indicate also a greater resemblance to the same organs in Molluscs than to those of Annelids. When eyes exist in Annelids, they are arranged in pairs on both sides of each articulation or else form a crown on one of the anterior rings. In Planariæ we find the eye-specks irregularly grouped on the upper surface near the anterior region of the body. The same arrangement is observed in Nemertes. This arrangement forcibly reminds us of what we see in Gasteropods. In Planariæ alone they are more numerous and distributed with less constancy, a fact which is accounted for by the lower position of that family in the class.

The habits of Nemertes and Planariæ speak rather in favor of Molluscs than worms. Most of them live concealed under stones which is the case with many Molluscs, while I do not know any which lives within a tube constructed like those of worms.

The embryonic development of both Nemertes and Planariæ takes place according to the laws we witness among Gasteropods. The larval condition of both Gasteropods and Planariæ is very similar.

It is plain enough, Nemertes and Planariæ are only *analogous* to Articulata; by their *affinities* they are Molluscs. The division of Articulata hence appears to us as a type more natural and rational, as well as that of Mollusca: this latter including all animals which are soft, slimy and flabby, whatever may be their form.

* * * * * * *

The Rhabdocœlæ or freshwater Planariæ will be the connecting link by which the Nemertes approach Planariæ proper, as members of the same group. We may say of them that they are the freshwater representatives of both Nemertes and Planariæ. And now observe the transition: the group, Rhabdocœlæ, which is distinguished at once from Planariæ and Nemertes, this group, I repeat, lives in fresh waters, while the other two groups which they connect together are scarcely found beyond the boundaries of the seas. If some of them ascend the rivers it is within the limits where the water still retains a part of its marine character.

So that the connection although materially expressed, exists essentially in their immaterial essence.

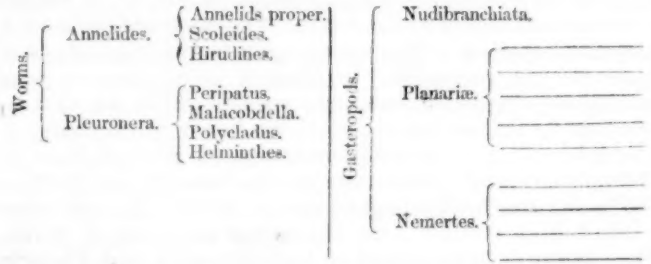
VI.

I now conclude by a few words on Annelids and Gasteropods.

Having withdrawn from the first of these classes a certain number of its representatives to include them among the second, it is to be expected that I should present in a synoptical manner the systematic modifications resulting from it.

If we admit the two sections of worms proposed by Milne Edwards, the Pleuronera and Annelids proper, we should place them one above the other to form a single series instead of one.

Opposite we should have the series of Gasteropods beginning with Nemertes; above these the Planariæ, then the Nudibranchiata;



What would come next to the Nudibranchiata I am not prepared to say. The series cannot go on, on that footing, for the very simple reason that embryology assigns a lower rank to all Gasteropods provided with a shell, inasmuch as Nudibranchiata, when hatched, have a shell, which they lose at an early period of their life. The attempt at forming organic series in the animal kingdom is one of the most difficult of labors, and a work of a relative value. Unless several series are established in the class of Gasteropoda, the position of Nudibranchiata in the above synopsis cannot be accounted for. I have already made the remark that Planariæ were rather parallel to Nudibranchiata than of a lower rank, finding in these two families groups of equal importance.

Respecting the serial arrangement of worms, as given above, and resting upon the morphology of their nervous system, I have also to remark, that it does not coincide with another series alluded to in a remarkable paper of late publication;* and indeed if lumbricine Annelids and Leeches are higher in their class, as I be-

* The natural relations between Animals and the Elements in which they live; by Prof. L. Agassiz. This Journal, 2d ser., vol. ix, p. 369.

lieve it, this fact corroborates the idea that the nervous system characterizes only the primary divisions. And our position would turn out to be the right one.

If instead of a single series, or several series with a starting point and an end, we construct a circle or an ellipse, and place the Gasteropods on its circumference, then the arrangement of each group would meet with less difficulty and perhaps satisfy completely the mind.

Cambridge, Mass., October, 1850.

ART. V.—*Memoir on Emery;* by J. LAWRENCE SMITH, M.D.—Second part.—*On the Minerals associated with Emery: Corundum, Hydrargillite, Diaspore, Zinc spinel, Pholerite, Ephesite* (a new species), *Emerylite* (a new species), *Muscovite, Chloritoid* (a new variety), *Black Tourmaline, Chlorite, Magnetic Oxyd of Iron, Oligiste Iron, Hydrated Oxyd of Iron, Iron Pyrites, Rutile, Ilmenite and Titaniferous Iron.*

Read before the Academy of Sciences of the French Institute, July 15th, 1850, and communicated by the author for this Journal.

Now that it has been shown that emery is found in considerable abundance in certain parts of the world,* occupying almost the position of a rock; it is useful to mention the different accidental minerals or *minerals of elimination*, that are found with emery, and what new facts have been observed with relation to them. Corundum may be first mentioned.

Corundum.—Although emery is constituted principally of corundum, the examination of this substance in its pure state, or rather in the form of those prismatic crystals which I have sometimes found in contact with emery, has brought to light several new and well established facts that could not have been satisfactorily ascertained from a mixed mineral like emery.

At *Gumuch-dagh*,† it is not difficult to find large pieces of this mineral, pure or mixed with a little diaspore and emerylite; sometimes the crystals are very distinct, under the form of six-sided prisms. The small crystals found in the cavities are sometimes terminated by a summit of six faces. The color of the corundum found in the different places alluded to in this memoir, is blue, except that of Kulah and of Adula, which is of a greenish grey. All that I have to add to what is already known of this mineral,

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* For the *First Part* of this memoir, see the last volume of this Journal, pages 354–369.

† See the *first part* of this memoir for a description of the localities, this Journal, x, 354.

relates to its *composition* and *effective hardness;* the latter was ascertained in the way already described in speaking of the emery, and it has been found to vary with the composition of the mineral. The analyses were made in the same manner as those of the emery, and the results which I have obtained are as follows:—

	CORUNDUM.		COMPOSITION.					
Localities.	Effective hardness. Sapphire 100.	Sp. grav.	Water.	Alumina.	Magnetic ox. iron.	Lime.	Silica.	Manganese.
Sapphire of India, ...	100	4·06	——	97·51	1·89	——	0·80	——
Ruby of India, ...	90	——	——	97·32	1·09	——	1·21	——
Corundum of Asia Minor.	77	3·88	1·60	92·39	1·67	1·12	2·05	trace.
Corundum of the island of Nicaria, ...	65	3·92	0·68	87·52	7·50	0·82	2·01	——
Corundum of Asia,....	60	3·60	1·66	86·62	8·21	0·70	3·85	——
Corundum of India,....	58	3·89	2·86	93·12	0·91	1·02	0·96	——
Corundum of Asia,....	57	3·80	3·74	87·32	3·12	1·00	2·61	——
Corundum of India,....	55	3·91	3·10	84·56	7·06	1·20	4·00	0·25

The most remarkable fact ascertained by these analyses, is the presence of water in variable quantity in all varieties of the corundum except the sapphire and ruby. To me this fact has a certain value in proving that the corundum and the sapphire are formed under different circumstances and do not belong to the same geological formation. The different structure of these two species of corundum might make one suspect a difference in the condition of their formation; and this is somewhat confirmed by the results of the beautiful experiments of M. Ebelmen in making artificial corundum by subjecting alumina and borax to the heat of a porcelain furnace for many hours; circumstances under which he always obtained crystals under some of the modifications of hyaline corundum, and never as prismatic corundum. In addition to this, I remark that in my most thorough examination of the localities of emery, not the slightest trace of sapphire or ruby was found.

The quantity of water found to exist in corundum, coming from different localities, is variable, and it would appear that all other things equal, those containing the least water are the hardest. I will not insist on the slight difference between the hardness of the sapphire and ruby, having made only one experiment upon each of these minerals.

The two varieties of corundum are so evidently united by their system of crystallization, that I would not undertake to separate them on account of the presence of water in one of them, and that in variable quantity; nevertheless, the fact is important as it explains to a certain extent their differences in structure and hardness. I would remark that great pains was used to ascertain whether the water might not be due to the presence of diaspore

or some other hydrate of alumina; but after the most careful and repeated examinations, this has been decided in the negative.

Hydrargillite.—Hydrargillite is rarely met with. I have one specimen with this mineral forming the external coating of a crystal of corundum, and also a hexagonal prism of the same mineral. It was not analyzed, but its physical properties and its reactions under the blowpipe served to prove its identity with this mineral. The specimen in my possession comes from *Gumuch-dagh.*

Diaspore.—This mineral up to the present time has not occupied a very important position in mineralogy, and has been found only in two or three localities. In the course of this article, I hope to show that it plays a somewhat important part in the emery and corundum formations. Before my attention was drawn to the minerals, first discovered by M. Lelievre, it was studied by M. Dufrenoy, on that coming from Siberia, and by M. Haidinger on the diaspore of Schemnitz. Before going farther I would remark, that the gangue of the latter which has been described as analogous to steatite, was found by me not to be such, but a hydrated silicate of alumina, similar to one found with the emery of Naxos.*

To the localities of diaspore already known, I have to add those of *Gumuch-dagh* and *Manser* in Asia Minor, and the islands of *Naxos*, *Samos*, and *Nicaria*, in the Grecian Archipelago; and there is reason to suppose that this mineral will be found in almost every corundum locality. I have already found it on crystals of corundum from China.†

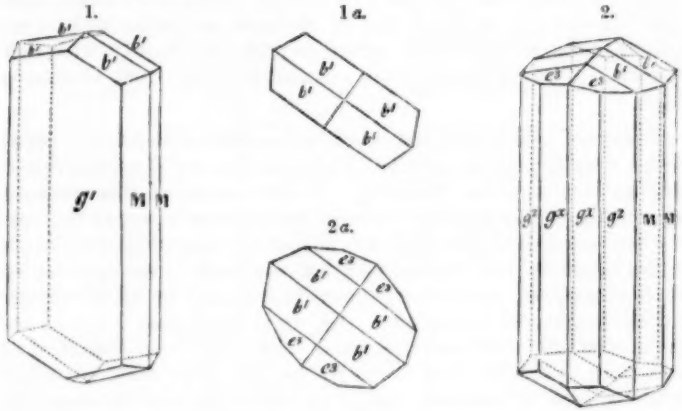
In examining the emery formations, one of the first things that struck my attention was the existence of diaspore and corundum together, then observed for the first time. The same year, M. Marignac discovered it in the limestone of St. Gothard, along with the well known crystals of corundum that exist there. Having found the diaspore under these new circumstances it has been examined with much attention.

At Gumuch-dagh the diaspore is found in flattened and rounded prisms with the surface streaked with lines that afford by reflected light an iridescence. Crystals with perfect summits are rarely found, and during two or three days examination on the place I found only five small crystals with one of the summits perfect, they were however, very beautiful and finer probably

* The gangue of the Schemnitz diaspore has been examined by Hutzelmann, see this Journal, [2], x, 247, and Pogg. Ann., lxxviii, 575, who makes it to contain three distinct hydrates of alumina; but this fact cannot be considered as sufficiently established. One of these hydrates is named *Dillnite*, and another is near Agalmatolite.

† Prof. C. U. Shepard has found diaspore with topaz at Trumbull, Conn.

than any yet known. Not wishing to lose so favorable an occasion to verify the crystallography of diaspore, I requested M. Dufrenoy to undertake the measurement of the angles, and it is to this able professor that we are indebted for the crystallographic results here given.*



The crystals are elongated needles crossing each other in all directions like an acicular variety of arragonite from the Vosges. They resemble small crystals of topaz in lustre and in the disposition of the vertical striæ on the faces *g*. Their color is yellowish white. They are strongly dichroitic, the summits under certain inclinations appear black as if the light was completely polarized. The cleavage is very easy parallel to the face g^1, and it is this cleavage that gives a lamellar structure to that diaspore which is not in the form of needles. This cleavage notwithstanding its facility does not expose surfaces that reflect with great accuracy; it is the only angle which offers the difference of a half degree; repeated measurements of the other angles never varied more than four minutes. The pearly lustre of the cleavage in connection with its striated character are the causes of this difficulty which at first sight would not appear to exist, only becoming evident when the angle is examined.

The crystals, very much flattened parallel to the face g^1, are represented by figures 2 and 3; the face g^1 does not exist, being replaced by three series of faces *g*, the angles of which could not be measured, but the almost absolute identity of these crystals with those of St. Gothard, which M. Marignac first described,

* Three of the crystals measured are in the Cabinet of the School of Mines and Garden of Plants at Paris.

The second crystal above is nearly as thin as the first, although represented thicker in order to show well all the planes.

authorizes one to suppose that they are represented by the crystallographic signs g^2 and $g\frac{1}{3}$. The faces M and those of the summit have a very bright lustre. The primitive form of the diaspore is undoubtedly a right rhombic prism of 130° 2′; the fact that the base is horizontal, is shown by the identity of the angles of the faces b^1 on the anterior faces M, and the faces b^1 on the posterior faces of the same. This position is verified in seeking for the angle of the edge b^1 on M, which ought to be a right angle; in fact the calculation of a spherical triangle composed of the faces M, b^1 and g^1, of which all the angles of incidence were measured, gave for this edge 90° 2′ 30″, which differs from a right angle by only two minutes and a half.

The following table is made up of the measurements of the angles of the diaspore of Gumuch-dagh (near Ephesus) by M. Dufrenoy, of that of St. Gothard by M. Marignac, and of that of Schemnitz by M. Haidinger, also the measurement of some angles of the hydrated peroxyd of iron of Cornwall, by M. Dufrenoy, which are here given to show an interesting connection, first pointed out by M. de Senarmont, and which consists in the isomorphism of diaspore and the hydrated oxyd of iron. Thus while the peroxyd of iron or oligiste iron is isomorphous with alumina or the corundum, the hydrates of the same oxyds are isomorphous.

	Diaspore of St. Gothard, *Marignac.*	Diaspore of Schemnitz, *Haidinger.*	Diaspore of Gumuch-dagh near Ephesus, *Dufrenoy.**	Hydrated Oxyd of Iron, of Cornwall, *Dufrenoy.*
M : M	130°	129° 54′	130° 2′	130° 57′
M : b^1	.....	.....	125° 17′	
M : b^1 (posterior faces),	.....	.....	125° 18′	
M : g^1	115°	.....	114° 58′	
b^1 : g^1	104° 12′	.....	104°	
b^1 : b^1	151° 36′	151° 36′	151° 35′	
b^1 : b^1 (posterior faces),	.....	.....	151° 33′	151° 34′
b^1 : b^1 (opposite faces),	116° 38′	.....	116° 18′	
b^1 : c^3	.....	.....	167° 6′	
g^1 : g^2	144° 40′	.....		
g^2 : g^2	145° 40′	.....		
i : i	126° 12′	.....	.....	126° 20′
g^1 : i	116° 56′	.....	.....	116° 55′
$e^{\frac{1}{2}}$: $e^{\frac{1}{2}}$	117° 46′	.....	.....	117° 10′

I have found crystals of diaspore in hydrated oxyd of iron, the needles traversing the oxyd in all directions. There is a specimen in my possession composed of a small crystal of diaspore, surrounded by a kind of scabbard of crystallized göthite; one of the summits of the crystal is exposed. In breaking the oxyd of iron which contains these crystals, they become detached, leaving on the oxyd an impression with a very brilliant surface.

* The values of these angles are just as given by the goniometer without any correction by calculation.

The diaspore of Gumuch-dagh is also found, of a lamellar structure, but very rarely; that of Naxos, Nicaria and Samos are all lamellar. Yet of all the specimens that I have collected none offer so much interest as those composed of diaspore imbedded in corundum; here we see the two minerals passing one into the other, without being able, in many places, to distinguish the line of separation, so imperceptible is the gradation. After what has been said in respect to corundum, it is not astonishing to see this connection of alumina more or less hydrated with a hydrate of alumina of definite composition.

After a knowledge of this fact one might seek to explain the existence of water in corundum, by the intimate mixture of diaspore with this mineral; if this be the case, the crystal of corundum from the Carnatic, which gave me three per cent. of water, must contain twenty-three per cent. of diaspore, although neither the eye nor microscope could detect its presence.

As to the properties of diaspore, I have nothing to add to what has already been published on the subject, except that the specimens I examined do not decrepitate to the same extent as that of Siberia. Its specific gravity is 3·45 and hardness above 7. The following analyses were made, the mineral being attacked with the bisulphate of soda. They afford the formula, $\dot{A}l\,\dot{H}$.

Localities.	Silica.	Alumina.	Lime.	Oxyd of Iron.	Magnesia.	Water.
Gumuch-dagh,	0·67	82·20	0·41	1·20	*trace.*	14·52
Gumuch-dagh,	0·82	83·12	*trace.*	0·66	*trace.*	14·28
Naxos,	0·26	82·94	0·35	1·06		14·81

Zinc Spinel.—I possess a single specimen of this spinel in chloritoid on a piece of emery from Gumuch-dagh; it is in octahedral crystals agglomerated, of a dark emerald green color; the quantity being small I have been prevented from making an exact analysis. The quantity of oxyd of zinc appears to be from thirty to forty per cent.

Pholerite.—A mineral, resembling pholerite in composition, has been found with the emery of Naxos associated with emerylite. It is white, lamellar, and somewhat crystalline, sometimes grey. It is soft to the touch like steatite, infusible before the blowpipe, and when heated with nitrate of cobalt becomes strongly colored blue. It is scratched with the nail, and has a specific gravity of 2·564. Its composition is identical with the pholerite of Guillemin, also with the mineral forming the gangue of the diaspore of Schemnitz. For analysis it was decomposed with carbonate of soda. It afforded:—

		Pholerite of Guillemin.	Gangue of diaspore of Schemnitz—Smith.
Silica,	44·41	42·93	42·45
Alumina,	41·20	42·07	42·81
Lime,	1·21		*trace* and mag. *trace.*
Water,	13·14	15·00	12·92

This corresponds to the following formula, $\ddot{S}i\,\dot{A}l+2\dot{H}$, but it is a question whether or not we should consider the water as existing in any definite proportion, and whether or not they did not all contain more water when first taken from their localities. These hydrated silicates of alumina are numerous, and bear various names, but it is doubtful if many of them are entitled to much consideration as distinct species.

Ephesite, (a new species.)—This silicate is found with the emery of Gumuch-dagh and occurs on specimens of magnetic oxyd of iron. It is of a pearly white color, and lamellar in structure; cleavage difficult. It scratches glass easily, and has a sp. grav. of from 3·15 to 3·20. Heated before the blowpipe it becomes milk-white, but does not fuse. At first sight it might be taken for white disthene. It is decomposed with great difficulty by carbonate of soda even with the addition of a little caustic soda. I used also very successfully in the analysis the bisulphate of soda either in attacking the mineral from the commencement, or in operating first with carbonate of soda, and then acting on the part not decomposed with bisulphate of soda. The alkalies were separated by means of hydrofluoric acid.

Silica,	31·54	30·04
Alumina,	57·89	56·45
Lime,	1·89	2·11
Protoxyd of iron,	1·34	1·00
Soda with a little potash,		4·41
Water,	3·12	3·06

This corresponds very nearly to the formula

$$\dot{R}^2\,\ddot{S}i+5\dot{A}l^2\,\ddot{S}i+4\,\dot{H}.$$

	Atoms.	At. weight.	Pr. ct.	Oxygen ratio.
Soda,	2	781·6	7·08	1
Silica,	6	3400·2	30·77	9
Alumina,	10	6416·2	58·08	15
Water,	4	450	4·07	2

This mineral has been designated *Ephesite* because of its occurrence at the emery locality near the ancient city of Ephesus.

Emerylite, (a new species.)—This mineral which I have designated by the name of Emerylite is a new species belonging to the family of micas. I have already published a note indicating its existence,* but have reserved for the present time a complete description of it.

I first discovered this mineral with the emery of Gumuch-dagh in Asia Minor, and subsequently in that of Manser, the islands of Naxos and Nicaria, and also with the emery of Siberia.

* See this Journal, 2nd ser., vii, 285, 1849.

Its connection with all the emerys that have come under my observation except that of Kulah, induced me to call it *Emerylite.* When I announced this discovery to Prof. Silliman, Jr., he hastened to examine the minerals coming from the corundum localities of the United States, and has succeeded in finding the emerylite with the corundum of several localities.* The specimen from Siberia on which I found this mineral is in the collection at the Garden of Plants at Paris, and I have also reason to think that I have found it with the corundum of China.

The emerylite is lamellar like mica, the plates are easily separated, and possess a little elasticity. Sometimes it is in the form of a mass composed of very small pearly scales, which are very friable, resembling some species of talc. The plates are commonly convex and concave, grouped in such a manner as to form a triangular prism. I have also found it massive with a micaceous structure, but with an irregular fracture; the aspect of this variety is waxy: it comes from Gumuch-dagh. The crystalline form of this mineral is difficult to determine, but if we are permitted to judge from the streaks on the surface, and the imperfect cleavage in two directions, it would appear to belong to an oblique rhombic prism.

Its color is white and lustre silvery; the hardness taken on a specimen from the island of Nicaria is from 4 to 4·5. The sp. grav. taken on ten specimens varies from 2·80 to 3·09; this difference is not remarkable in a lamellated mineral. That which gave me the greatest specific gravity contained some small specks of titaniferous iron visible to the eye. Its optical properties have not been examined, for the want of a transparent piece of sufficient size and thickness. This mineral is not attacked by the acids; heated before the blowpipe it emits a bright light and melts with great difficulty on the edges, which assume a blue color if touched with the nitrate of cobalt and reheated. Heated in a tube it furnishes water frequently having an acid reaction due to fluoric acid.

The composition of several specimens subjected to analysis is as follows:—

Localities.	Silica.	Alumina	Lime.	Oxyd iron.	Magnesia.	Potash & soda.	Water	Manganese.
Gumuch-dagh, ...	29·66	50·88	13·56	1·78	0·50	1·50	3·41	——
Island of Nicaria, ...	30·22	49·67	11·57	1·33	*trace.*	2·31	5·12	——
" "	29·87	48·68	10·84	1·63	*trace.*	2·86	4·32	——
Island of Naxos, ...	30·02	49·52	10·82	1·65	0·48	1·25	5·55	——
" "	28·90	48·53	11·92	0·87	not estimat'd	not estimat'd	5·08	——
" "	30·10	50·08	10·80	not estimat'd	"	"	4·52	——
Gumuch-dagh, ...	30·90	48·21	9·53	2·81	"	"	4·61	——
"	31·93	48·80	9·41	1·50	"	2·31	3·62	*trace.*
Siberia, ...	28·50	51·02	12·05	1·78	"	not estimat'd	5·04	——

* See this Journal, viii, 379, and Dana's Mineralogy, pp. 362 and 689.

The oxyd of iron may be regarded as an impurity which exists between the plates of the mineral. The composition of the emerylite is represented by

	Atoms.	At. Weight.	Pr. ct.	Oxygen ratio.
Lime,	2	700·	13·48	2
Silica,	3	1700·1	32·74	9
Alumina,	4	2566·5	49·44	12
Water,	2	225·	4·34	2
		5191·6		

Formula, $\dot{R}^2\,\ddot{S}i+2\dot{A}l^2\,\ddot{S}i+2\dot{H}$,

As is seen, the specimens examined came from four distinct localities, and were all taken under different circumstances; yet their analyses accord perfectly, and also agree with those of the United States coming from Village Green and Unionville of Pennsylvania, and Buncombe County, North Carolina.*

Localities.	Silica.	Alumina.	Lime.	Magnesia.	Potash & soda.	Water.		
Village Green,	32·31	49·24	10·66	0·30	2·21	5·27	=100	*Craw.*
"	31·06	51·20	9·24	0·28	2·97	5·27	=100	*Craw.*
"	31·26	51·60	10·15	0·50	1·22	4·27	=100	*Craw.*
"	30·18	51·40	10·87	0·92	2·77	4·52	=100·46	*Craw.*
Unionville,...	29·99	50·57	11·31	0·72	2·47	5·14	=100·10	
"	32·15	54·28	11·36	0·05	not estimat'd	0·50	Fe *trace,*	*Hartshorne.*
Buncombe Co.,	29·17	48·40	9·87	1·24	6·15	3·99	HF 2·03 =100·80	*Silliman, Jr.*

My analyses were made in the ordinary way, only with more carbonate of soda than is usually employed. The alkalies were separated either by means of hydrofluoric acid or by carbonate of lime, which is preferable to the carbonate of baryta for the decomposition of the silicates.

It is seen that potash and soda are present in small quantities in all the specimens. The composition of this mineral is remarkable for the large proportion of alumina present; but when we look at its origin it is not astonishing to find a silicate of alumina with a small amount of silex.

I regard emerylite as a mineral of elimination from emery, the result of an effort by which the corundum in its formation purifies itself. It is not remarkable that from the mass in which the corundum crystallizes, the silica finding itself in presence with an excess of bases, combines with as large a quantity as its affinity will admit of. In speaking of the formation of emery, I have already alluded to a nodule in my possession that exemplifies this in a very exact manner.

* See Dana's Mineralogy, 3d edition, p. 362.

Notwithstanding the recent discovery of emerylite there is no other species of mica that can be considered so well established as this mineral, or so constant in its composition. Up to the present time this mineral has not been found except with emery or corundum, which frequently contain it in the interior of the mass as well as on the surface. Some emerys contain it in such quantity that it has the aspect of gneiss, as I have already said with reference to certain specimens from Nicaria.

The most beautiful specimens of emerylite come from Naxos; and as the blocks of emery from this island frequently contain it, there will be no difficulty in procuring specimens for cabinets. It is often mixed with diaspore.

Mica, (Muscovite?)—This mica is found on all the emerys which I have examined, but especially on that coming from Kulah. It is always in small plates on the surface of the emery. The analyses of four specimens are as follows:—

Localities.	Silica.	Alumina.	Lime.	Oxyd of iron.	Magnesia.	Pot'h with little soda.	Water.	Manganese.
Gumuch-dagh, ...	42·80	40·61	3·01	1·30	*trace.*	not estimated.	5·62	*trace.*
Kulah, ...	43·62	38·10	0·52	3·50	0·25	7·83	5·51	*trace.*
Kulah, ...	42·71	37·52	1·41	2·32	*trace.*	not estimated.	5·95	*trace.*
Island of Nicaria, .	42·60	37·45	0·68	1·70	*trace.*	9·76	5·20	*trace.*

The composition is very nearly that of the muscovite or Muscovy glass, and until farther examination, I shall retain it under that species, as particular care should be exercised in making new species among the micas.

Chloritoid, (a new variety of this mineral.)—It is found with the emery of Gumuch-dagh in considerable abundance. Its structure is lamellar, cleaving without much difficulty, and the surfaces exposed are always very brilliant. In thin fragments it transmits the light and appears of a dark green color. The powder is greenish grey. Its hardness is 6, and specific gravity 3·52. Heated in the flame of the blowpipe it loses water, and becomes brown from the absorption of oxygen but does not melt. When heated without being in contact with the air it loses its brilliancy, and acquires the aspect of scales from the blacksmith's forge.

This mineral is attacked by the strong acids but is only completely decomposed by sulphuric acid. Melted with four or five times its weight of carbonate of soda it is rendered easily soluble in hydrochloric acid. Great precaution was taken to see that nothing but perfectly pure chloritoid was submitted to analysis, and the possession of well crystallized specimens enabled me to do this without much difficulty.

The method of analysis, was to break the mineral in small fragments, to place it in a small platinum crucible, which was introduced into an earthen crucible and surrounded by pulverized quartz: in one word, I pursued the same method as that for estimating the water in emery. For the other ingredients, a new portion was taken, pulverized finely, and attacked either by concentrated sulphuric acid or melted with carbonate of soda, and afterwards dissolved in hydrochloric acid with the addition of a little nitric acid evaporated to dryness, and treated with dilute hydrochloric acid. The liquid separated from the silica is treated with an excess of caustic soda, and the filtered liquid is neutralized by hydrochloric acid and the alumina precipitated by carbonate of ammonia.

The contents of the filter which are essentially peroxyd of iron, are placed in a capsule, dissolved by hydrochloric acid, heated and precipitated by ammonia and thrown on a filter. From the filtered solution the lime and magnesia are separated in the ordinary way. The peroxyd of iron remaining on the filter after being well washed and dried, is weighed and decomposed in a current of hydrogen gas. To the oxyd thus reduced, nitric acid diluted with thirty times its weight of water is added, and digested at 100° to 120° C. for about an hour, stirring frequently, when if the iron has been thoroughly reduced it will be taken up by the acid, and a little alumina left which is weighed and added to the first portion. Ordinarily I never have found more than from one to two per cent. of alumina with the oxyd of iron. Care must be taken to decompose the iron completely, as otherwise the iron will not be entirely taken up by the acid. The mineral thus analyzed afforded as follows:—

	Silica.	Alumina.	Protox. of iron.	Water.	Lime.	Magnesia.	Titanic acid.	Manganese.	Potash & soda
Decomposed by sulphuric acid,	24·10	39·8	27·55	6·5	not estimat'd	not estimat'd	not estimat'd	not estimat'd	0·30
Decomposed by carb. soda, ...	23·94	39·52	28·05	7·08	0·45	0·80	*trace.*	0·52	——
Decomposed by carb. soda, ...	23·20	40·21	27·25	6·97	0·83	0·95	*trace.*	not estimat'd	——

These analyses correspond to the following composition.

	Atoms.	At. weight.	Pr. ct.
Silica,	2	1133·40	23·87
Alumina,	3	1925·88	40·57
Protoxyd of iron,	3	1350·00	28·44
Water,	3	337·50	7·12

The most probable formula is

$$\dot{Al}^2\,\ddot{Si} + \dot{Fe}^3\,\ddot{Si} + 3\dot{H}.$$

The minerals which are brought under this species are the chloritspath or chloritoid of the Ural, the Sismondine of St. Marcel and the Masonite of Rhode Island; their analyses and formulæ are as follows:—

	I.	Oxygen.	II.	Oxygen	III.	Oxygen.	IV.	Oxygen.	V.	Oxygen.	VI.	Oxygen.
Silica,.....	27·48	6	24·40	2	24·1	9	28·27	6	25·18	5	23·91	2
Alumina,..	35·37	6	45·17	3	44·2	15	32·16	6	33·61	6	39·52	3
Protox. of iron, ...	27·05	3	30·29	1	23·8	4	33·72	3	35·31	3	28·05	1
Magnesia,..	4·29											
Water,.....	6·95	3	....	..	7·6	5	5·00	2	5·88	2	7·08	1

I. Chlorite spar or Chloritoid of the Ural by Bonsdorff. $(\dot{Fe}, \dot{Mg})^3\ddot{Si}+\ddot{Al}^2\ddot{Si}+3\dot{H}$.

II. Chlorite spar of the Ural, Erdmann. $\dot{Fe}^3\ddot{Al}+2\ddot{Al}\ddot{Si}$.

III. Sismondine of St. Marcel, Delesse. $\dot{Fe}^4\ddot{Si}^2+5\ddot{Al}\dot{H}$.

IV. Masonite of Rhode Island, Whitney. $\dot{Fe}^3\ddot{Si}+\ddot{Al}^2\ddot{Si}+2\dot{H}$.

V. Chlorite spar according to Rammelsberg requires, $3\dot{R}^3\ddot{Si}+2\ddot{Al}^2\ddot{Si}+6\dot{H}$.

VI. Chloritoid of Asia Minor, J. L. Smith. $\ddot{Al}^3\ddot{Si}+\dot{Fe}^3\ddot{Si}+3\dot{H}$.

This mineral is found very abundantly with the emery of Gumuch-dagh; it covers the surface of the blocks, and sometimes enters largely into the substance of the emery. It is easy to see from the composition of this mineral, that it is formed by elimination from the mass of emery at the time of its consolidation, which by this means tends to purify itself. The nodule of which I have already spoken under the head of emery and of emerylite goes to sustain this view of the question.

On the emery of the other localities, I have not found this chloritoid. Its composition is not in perfect accordance with the known varieties of chloritoid, and differs from Sismondine (which it approaches most in composition) by its imperfect solubility in hydrochloric acid.

Black Tourmaline.—This mineral is found abundantly with the emery of Naxos, and also in small quantities with that of other localities. It appears to have replaced the chloritoid that is found so abundantly with the emery of Gumuch-dagh.

The crystals are found agglomerated on the surface, and also disseminated in the interior of the emery. This mineral like the last is strongly basic, containing a little more than thirty per cent. of silica.

Chlorite.—With the emery of Gumuch-dagh we find a chlorite. It is in compact masses composed of an agglomeration of small crystalline plates, and contains octahedral crystals of magnetic oxyd of iron. Analysis gives as its composition,

Silica,	27·20
Alumina,	18·62
Protoxyd of iron,	23·21
Magnesia,	17·64
Water,	10·61

It is identical with the chlorite of *Mont des sept-Lacs* which gave M. Marignac,

Silica,	27·14
Alumina,	19·19
Protoxyd of iron,	24·76
Magnesia,	16·78
Water,	11·50

It is the same as the chlorite of *St. Christophe* and the ripidolite of *Rauris* and of *St. Gothard.* The formula given by von Kobell is,

$$2\dot{M}g\,\ddot{A}l+3(\dot{M}g\,\dot{F}e)^2\,\ddot{S}i+6\dot{H}.$$

Magnetic Oxyd of Iron.—This is found with the emery of every locality. It enters into the composition of the emery itself and is also found on the surface in regular octahedral crystals. We find it frequently massive and of strong polarity. That of Gumuch-dagh contains a trace of titanic acid.

Oligiste Iron.—It is associated with all the emerys, and sometimes enters into their composition. It is also found in detached masses, either amorphous or as crystallized specular iron.

Hydrated Oxyd of Iron.—This oxyd of iron is not unfrequently found with emery, covering the surface. It is found with pyrites having resulted from the decomposition of this mineral.

Iron Pyrites.—Pyrites is found principally with the emery of Gumuch and Nicaria. At the latter locality it is in small crystals in the interior of the mass. At Gumuch it is principally on the surface but much less abundant than at Nicaria.

Rutile.—This oxyd of titanium is found with the emery of Gumuch-dagh and of Kulah, where I obtained some large detached crystals. I have also a specimen, with it in small crystals on diaspore attached to emery from Gumuch-dagh.

Ilmenite.—It has been found on the gangue of the emery of Kulah in minute crystals, of the usual form of this mineral.

Titaniferous iron.—Titaniferous iron is found with almost all the varieties of emery that I have examined, but I have analyzed none but that associated with the emery of Nicaria. Care being

first taken to see that it was anhydrous, one gramme of it was calcined in a current of oxygen and it augmented ·019, which indicated the presence of ·171 gramme of protoxyd of iron, and corresponds to ·190 gramme of peroxyd of iron; the same portion then decomposed by a current of hydrogen gas and the loss sustained was equal to ·222 gramme of oxygen, which corresponds to ·740 gramme of peroxyd of iron; deducting from this the quantity of peroxyd equal to the protoxyd (·171) contained in the mineral, we have ·550 gramme for the quantity of peroxyd present. The mass reduced by hydrogen was treated with hydrochloric acid, and the part not dissolved (·230 gramme) was titanic acid with a little alumina. The acid solution contained ·010 lime, and a trace of alumina. The titanic acid was examined as to its purity and was found to contain no silica, and only a trace of alumina. The result of the analysis is,

Protoxyd of iron,	17·10
Peroxyd of iron,	55·00
Titanic acid,	23·01
Lime,	1·00
Alumina,	a little, not estimated.

This titaniferous iron corresponds in composition to the Washingtonite of Prof. Shepard as analyzed by M. Marignac, and to the titaniferous iron of Arendal analyzed by M. Mosander. Its sp. grav. is 4·78.

There are still two or three minerals that I have found associated with emery, but their specific characters have not been well established, on account of the difficulty of obtaining enough in a state of sufficient purity for analysis.

The study of these accidental minerals in contact with emery has led to several general conclusions which have been mentioned under the description of the different species; and now I do not risk much in saying, that the hydrates of alumina, as diaspore,—as well as the silicates, as emerylite, chloritoid and tourmaline,—and the minerals of iron, as magnetic, titaniferous iron, &c,—will be found almost everywhere with the emery and corundum.

My labors on this subject are thus terminated, and it is to be hoped that the examination of the emery of Asia Minor has served to elucidate the geology and mineralogy of this substance, until now but little known except in its uses.

ART. VI.—*On the Velocity of the Galvanic Current in Telegraph Wires;* by B. A. GOULD, Jr., in a Report to Prof. A. D. BACHE, LL. D., Superintendent of the U. S. Coast Survey.

DEAR SIR,—You did me the honor, last spring, to place at my disposal the materials derived from the telegraph experiments of the Coast Survey during the evening of Feb. 4, 1850, with an invitation to investigate them independently. I have accordingly devoted some labor to their discussion, and with your permission, will state the conclusions to which I have been conducted, in the same didactic form in which they were orally presented to the late meeting of the American Association held under your presidency at New Haven.

It may be permitted me, however, to add that I submit them with diffidence, for various reasons—not the least of which is that some of these conclusions are at variance with the known views of scientific friends, on whose judgment I place great reliance.

As but few have probably followed all the investigations on the subject, a large proportion of which have been published within a twelvemonth, it may be well for me to recapitulate to some extent what has already been done. Thus before detailing the results of the experiments of Feb. 4, I will endeavor to state the position of the theory before the discussion of those results. A peculiarity of the question consists in its intimate relation with the theory of electrical force, and the nature of conduction. This relation is so intimate as to render it almost impossible to discuss the subject without making use of phraseology derived from hypothesis. This may however be done with perfect safety—so long as we remember that such phraseology is only used for convenience of expression. If then I avail myself of such expressions as "electric current,"* for instance, "circulation," "wave," or similar phrases derived from hypothesis, plausible or otherwise, I will ask to be considered as using the terms in a metaphorical rather than in a literal sense. A simple idea may thus be expressed in a single word, while a carefully guarded circumlocution would otherwise be necessary, to distinguish "between the transmission of the effect and of the supposed fluid by the motion of whose particles that effect is produced."†

The ingenious experiment‡ of Prof. Wheatstone in 1834, tended to confirm the general opinion previously existing, that the velocity with which the electricity was transmitted by a metallic conductor was so enormous—so immense, indeed, compared with

* Faraday, Researches, i, pp. 81, 148.
† Id., i, p. 526.
‡ Phil. Trans., 1834, p. 583.

all other velocities known to us, excepting that of light—as to warrant the assumption of our incapacity to determine it. On this account, Wheatstone's elegant experiment obtained for its author the more distinction, and for his results the greater confidence. One of these results, as announced by him, was, that the velocity of electricity through the copper wires used, was indeed appreciable,—but exceeded that of light through the planetary space,* that it could not be less than 288,000 miles in a second, while light traverses about 196,000 during the same time.

The telegraphic observations, instituted under the immediate direction of Mr. Walker, by the U. S. Coast Survey, for determining the differences of longitude between remote stations in the United States, led to a very unexpected result,—viz.: that to obtain the greatest harmony among the several observations, a small correction must be introduced, depending on the relative distances between the telegraphic stations. No explanation of this phenomenon offered itself, excepting the hypothesis, suggested† by Walker, and communicated by yourself to the Am. Phil. Society in March, 1849, that the time elapsing during the passage of the signals between remote stations was much more considerable, and the velocity consequently less than had been before imagined.

Since Walker's results were first published, the subject has engaged the attention of numerous astronomers and physicists in Europe and America, among whom Mitchel, Fizeau and Steinheil are conspicuous. The subject belongs in itself far more properly to the domain of physics than to astronomy, but its special bearing upon the problem of longitude and the manner in which it has forced itself upon the consideration of astronomers have made it incumbent upon them to enter into a full discussion of the subject.

While in Washington in the month of February last, I accepted with pleasure an invitation from Mr. Walker to take part in an experiment on a very large scale, for which he had been long engaged in making preparation in behalf of the Coast Survey, and from which he anticipated results so ample as to put an end to the controversy. The Seaton Station of the Survey in Washington, north of the Capitol, and the city of St. Louis were connected on the 4th February, in one colossal galvanic circuit, and but for the damage occasioned by a storm on the same day, the circuit would have extended even to Dubuque in the territory of Iowa, a distance of some 1500 miles.

The wires of that line of telegraph, and of all I think which have been used in the experiments for velocity (with a single exception), are of iron, and of the size known in trade as No. 9,

* Phil. Trans., 1834, p. 591.

† Proc. Am. Phil. Soc., v. pp. 76. Astr. Nachr., xxix, 54.

being about three millimeters in diameter. We have every reason for believing that the velocity with which electricity is conducted, varies* with the conducting power of the medium, and should therefore naturally anticipate that this velocity would be found greater in copper than in iron. Wheatstone used in his experiment copper wire $1^{mm}{\cdot}7$ in diameter. Now the conducting power of iron is according to Lenz,† Riess,‡ and Pouillet,§ who determined it by different methods, less than $\frac{1}{7}\frac{3}{8}$ that of copper at 0°·C. And when we take this circumstance into consideration, it appears a sufficient ground for believing that the results of Walker and Wheatstone are not inconsistent with each other—even without reference to the fact that the one used the galvanic current, and the other machine-electricity of the highest possible tension.

Walker's first results,‖ derived from the longitude operations of the Coast Survey, led him to the opinion that the velocity with which the signals passed between Cambridge and Washington on the night of Jan. 23, 1849, was 18,690 miles a second, with a probable accidental error of 1000 miles.

On the night of Oct. 31, 1849, a series of experiments was made for the express purpose of determining the time needed for the transmission of signals. The results are published¶ in No. 7 of the *Astr. Journ.*, with a detailed account of the methods which he used, and an analytical investigation of the effects of those circumstances which could interfere with the accuracy of his results. The measurements of all the registers gave him for the velocity on that night 16,000 miles a second,—differing less than 1900 miles from his previous result and tending in general to confirm it. The final result at which he arrived was the general theorem,—that a signal given by breaking or closing the galvanic circuit at any point, was observed at other points on the circuit after intervals proportionate to their distance from the place where the signal was made,—and corresponding to a velocity of from 16,000 to 19,000 miles a second. Later experiments with the chemical telegraph are described** in No. 14 of the *Astr. Journ.*, and gives a still less velocity.

Prof. Mitchel, of the Cincinnati Observatory, dissents from the view taken by Mr. Walker, and attributes the results obtained by him to the effect of various sources of error and uncertainty in the methods which Walker has used. He devised a special and very curious apparatus for investigating the question,—and with the ingenuity and mechanical skill for which he is so eminent,

* Faraday, Researches, i, p. 423. † Pogg. Ann., xlv, p. 109. ‡ Id., xlv, p. 20.
§ Pouillet-Müller, Lehrb. der Physik, ii, p. 186.
‖ Proc. Am. Phil. Soc., v, p. 74. ¶ Astr. Journ., i, p. 49.
** Astr. Journ., i, p. 105.

constructed it at the Cincinnati Observatory, and made a large series of interesting experiments on the telegraph line between Cincinnati and Pittsburg.* Prof. M.'s view of the matter is, that after a signal is given by closing or by breaking the galvanic circuit,—an appreciable time elapses before this signal is communicated to any other station—and that it is then received by all simultaneously. He considers this in connection with the details of his experiment to indicate that two fluids circulate in opposite directions between the poles of a battery,—but that neither makes its influence perceptible until complete circulation of each† has taken place from pole to pole. The velocity of this circulation Prof. Mitchel infers to be about 30,000 miles a second.

Finally, Fizeau and Gounelle, in a paper published‡ last April, in the *Comptes Rendus* of the French Academy, express a want of confidence in Walker's results, and describe experiments of their own, made on a circuit of 374 miles—a distance which they characterize as enormous, although the circuit used in the first Coast Survey experiments of Jan., 1849, extended through 550 miles of wire between Cambridge and Washington, and terminated at stations 380 miles apart in a geodetic line. These gentlemen used a method totally different from either Walker's or Mitchel's, and found that it gave them 62,000 miles a second, as the velocity in an iron wire, 4 millimeters in diameter, and 110,000 as the velocity in a copper wire, $2^{mm}\cdot5$ in thickness. Their method is not unlike that of Jacobi's experiments§ at St. Petersburg in 1838 for the determination of the time necessary for the development of a galvanic current. The experiments appear to have furnished no data for an inference as to whether a signal is necessarily communicated to the several parts of the circuit after intervals proportionate to the distance, or not.

Such is the present state of the theory, to the best of my knowledge,—and it will be observed that the views in the most fundamental points are far from unanimous. Still greater differences of opinion exist in regard to the more special questions.

The experiments of Feb. 4, have, it appears to me, furnished ample materials for arriving at a decision on very many of the vexed points, and without farther introduction, I shall proceed to consider the nature of those experiments, the sources of error, and the amount of error introduced by them. Mr. W. has already done this very elegantly in the memoir‖ to which I have referred; but I will also briefly consider the subject here. It will then be more easy to enunciate the questions, to which a discussion of the

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* Astr. Journ., i, p. 13. *Astr. Nachr.*, xxx, p. 325.
† Faraday, Researches, i, pp. 518, 520, 521.
‡ Comptes Rendus, xxx, p. 437. § Pogg. Annalen, xlv, p. 281.
‖ Astr. Journ., i, p. 105.

experiments between Washington and St. Louis ought to furnish a reply.

In the electro-magnetic telegraph offices, using Morse's patent, signals are communicated by the magnetization of a piece of soft iron, in the form of a horse-shoe magnet, and placed within a helix of wire. When the current flows, the iron becomes magnetic, and attracts an armature placed before it and connected with a graving tool. An endless fillet of paper is kept moving beneath the graver, by means of clock-work, so that the fillet is unmarked when no current exists in the wire, but is grooved by the action of the tool while the circuit is closed.

Fig. 1, (see Plate,) represents the recording apparatus and its adjustments. M is the magnet, A the armature, which is held back by the spiral spring S, while the current is not flowing, but is attracted as soon as the circulation of the current through the helix of wire has rendered M magnetic. The tension of the spring is regulated by a key. H is the reel for the paper fillet which receives the record; N a guide for directing and compressing the paper upon the roller R^1. The roller R^2 receives motion from the wheelwork W, and communicates it to the paper fillet F. While the armature is attracted, the indentor at the end of lever L presses upon the fillet, marking a groove whose length (the motion being equable) is proportionate to the duration of the electro-magnetism in M. The armature is never allowed to touch the magnet, but the proximity of its approach is limited by the stop I. This and the stop O which limits the outward motion, are capable of adjustment by screws. The distance traversed by the armature in passing from the outer to the inner stop is technically called the *pass*.

As the wire may be coiled into any number of helixes in the course of a circuit, there is no practical limit to the number of intermediate stations, each of which may receive all the signals quite as well as the terminal station. But since the intensity of the current decreases rapidly, as the distance from the battery increases, in consequence of the imperfect insulation of the wires, Morse's ingenious application of a local circuit is used, that these signals may be distinctly registered.

Fig. 2 represents a station on the main line. The signification of the letters is the same as in fig. 1, the key K regulating the spring. The armature-beam C is connected with one electrode of the local battery, the other being connected with the metallic inner stop I. An attraction of the armature closes the local circuit, on which is the recording apparatus, and thus a very weak current may suffice to close the circuit of the local battery, which may be regulated to any degree of intensity required.

Let us now suppose that at one extremity of a long circuit the pendulum of a clock is made to interrupt the current for a mo-

ment at each oscillation, the circuit being restored immediately afterwards as before. We shall have on the registers of the several stations a series of lines alternating with pauses or blank spaces,—*dots*, as they are called, in the technical phraseology of the telegraph.

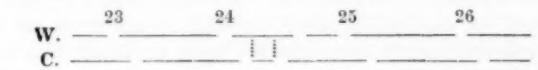
If the fillets were moved forward with a uniform velocity by the machinery of the registering apparatus, and no changes occurred in the intensity of the current in the wire, each of the lines upon any one fillet would be of the same length,—as also would each of the pauses. And if the velocity given to the fillets at the several stations were the same, the lines representing seconds would be of one length on all the registers. This last we cannot expect, nor is it in any manner necessary, for it is an easy matter to reduce all the registers to a uniform scale. But that the motion of each single fillet be uniform is very desirable. To obtain a near approximation to such uniformity requires machinery far more delicate and more carefully constructed than that which is in use in the telegraph offices, and with which the experiments of the Coast Survey have been made. Such apparatus has been devised and is constructing by Mr. Boyden of Boston, and by Mr. Bond of the Cambridge Observatory. It forms also an essential part of the apparatus of Prof. Mitchel. Yet, as we are in fact dependent on the rate of the driving machinery of the registering apparatus only for a single second in each case, the error from this source is reduced to that arising from the alteration of velocity between the beginning and end of the same second. This is very small, except in extraordinary cases, and we may assume that all errors of this kind eliminate themselves when we use the mean of a number of cases, instead of isolated observations.

At each station on the line of telegraph, during the experiments for velocity, a contrivance is introduced into the wire circuit, of such a kind, that the circuit may be broken by pressing upon a key, which is restored by a spring to its original position as soon as the pressure is removed. One of these "break-circuit" keys is represented at G (fig. 1). It is thus in the power of the operator at any station to break the circuit whenever he chooses, and in this way to communicate at once with all other stations on the line.

After a galvanic battery and the circuit-breaking clock have been connected with the line, we have at each station, a clock scale, that is, a series of lines, separated by short pauses, each pause corresponding to the beginning of a second, whose duration is denoted by the length of the grooved line. In the clock of this kind at Washington, that pause is omitted which corresponds to the beginning of each minute, and this enables us to identify on a fillet from any station, the clock-pause made at a

given second. But whatever the velocity with which the clock-pause is transmitted,—or, in other words, however great an interval may elapse after the pendulum has broken the circuit before the pause is recorded on the register-fillet of a distant station,—we have as yet no means of detecting it; for in comparing the registers made at different places, this interval will (other things being equal) be the same for all the pauses, and therefore remain undiscovered.

Let us, however, imagine that while the clock is graduating its scale on all the registers as before, an arbitrary signal is given by breaking the circuit at some distant station. The comparison of the several registers will thus enable us to register the interval which elapses between the giving and the receiving of a signal. To fix our ideas, suppose the clock to be at Washington, the arbitrary signal to be made at Cambridge, and the time requisite for the transmission of a signal between the two cities to be the thirtieth of a second. Then the clock-pause will be registered at Cambridge $\frac{1}{30}$th of a second after it took place and was recorded at Washington, and the arbitrary signal-pause will be recorded at Cambridge as soon as it is made, or $\frac{1}{30}$th of a second *before* it reaches Washington. We shall thus have the interval between the signal-pause and the preceding clock-pause longer at Washington than at Cambridge, and the excess on the Washington register will measure twice the time consumed in the transmission of the signals between the two stations.



In order to avoid accidental errors, the mean of many measurements may be used,—and half the mean excess of the interval between a clock-pause and the next succeeding signal pause gives us the time occupied for the transmission of a signal.

Such is the general method;—let us consider the possible sources of error and their probable influence. Every clock-pause and every signal-pause amounts in reality to a combination of two signals, distinct from one another, and subject to different general laws. The one consists of the electrotome, or breaking of the circuit: the other is the restoration of the circuit, or *electropœa*,—to use Mr. Walker's word.* We can consider the intervals between the signals as being the same as the intervals between the electrotomes, or beginnings of the pauses,—between the *electropœas*, or beginnings of the lines,—or as being more properly measured from the middle of one pause to the middle of the next. Mr. Walker has used the latter, the mean of

* Astr. Journ., i, p. 51.

the electrotome and electropœa readings.* For my own part, I prefer to use the electrotomes alone.

The only signal that can be made in a closed circuit is of course an electrotome. We break the circuit by tapping on the key. As soon as the finger is removed, the circuit is closed again by a spring, and an electropœa signal thus made. Do these two signals travel with the same velocity? If they do not, the clock-pauses must increase or diminish in length, as they are successively recorded at more remote stations. They must become elongated if the electrotome signal travel the faster, and contracted if the contrary. This question is an important one, but its discussion may be postponed for a while, as the length of the recorded pause is dependent on many other circumstances, and especially on the adjustments of the registering apparatus, which are not only very different at different stations, but appear to have been continually changed at the same station during the evening by the telegraph operators in charge of the registers. As far as I feel warranted in forming an opinion, I incline to the belief that these two kinds of signals traverse the circuit with equal speed,—or, to express the same idea in a different form, that induction of the electrical state in the successive molecules of the conducting medium, requires neither more nor less time than that required for a molecule to be restored to a condition of entire electrical equilibrium. The better to fix one's ideas in thinking on the subject, some hypothesis is desirable, which shall be capable of explaining all the phenomena; and I have accustomed myself to consider the propagation of electric polarity through a medium, as taking place† by the inductive force exerted upon each successive molecule‡ by the adjacent one.

If we consider the telegraph-wires as composed of a series of contiguous elements, an electrotome taking place at any point puts an end to the state of electrical tension in the nearest element on each side. The electrical equilibrium being restored in these elements, no force exists§ to continue the disturbance in the succeeding ones, and so on. An analogy to the propagation of an electropœa, or electric perturbation, may be drawn from the known laws of magnetism. If we have a curved rod of soft iron forming a little less than an entire circumference, and fill the gap with a bit of magnetic iron, the whole circle becomes magnetic. Although the period required for the transmission of this force is so short as to defy all attempts to measure it, there can be no doubt that a finite time intervenes between the introduction of the magnet and the magnetization of the most remote part of the

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* Proc. Am. Phil. Soc., v, p. 76. Astr. Nachr., xxix, p. 56.
† Faraday, Researches, i, § 1677. ‡ Ibid, § 1700.
§ Ibid, i, §§ 1671, 1686.

ring. When it is necessary to conceive some actual mode of transmission of signals, I am accustomed to represent it to myself in this way. The experiments of Wheatstone show that the electric spark took place at the same moment at points equidistant from the battery on the two sides, and latest at the point midway between the poles,—which is in perfect conformity with the hypothesis offered.* For the present, then, I may assume that electrotome and electropœa signals are transmitted with equal velocity; and, in a circuit composed of but one medium, in both directions.†

The circuit being suddenly closed, the electric disturbance is propagated through the telegraph-wire with a certain speed, and on reaching a registering station traverses the helix, imparting magnetic force to the encircled horseshoe of soft iron. The armature traverses the pass and closes the local circuit. The same phenomena are repeated in the local circuit and the graver attached to the armature-lever makes its mark upon the paper. All these processes require time, and the absolute interval, elapsed between the electropœa signal and its record on the paper fillet, is thus very considerably larger than that due to the time of transmission of the signal along the wire. The difference consists—

1st, of the *induction-time*, or time which elapses after the current is established in the helix, before sufficient magnetic power has been induced in the iron to overcome the tension of the spiral spring, and move the armature.

2d, of the *pass-time*, or time required by the armature for traversing the pass, and closing the local circuit.

3d, of the time of transmission of the electropœa in the *local* circuit.

4th, of the induction-time for the local-circuit magnet.

And 5th, of the pass-time in the same.

If the adjustments of the local circuit are good and are not changed during the experiment, and if the action of the local battery is constant, the last three quantities remain the same for all electropœa signals during the experiment, and exert no influence except in lengthening all the registered pauses by a very small quantity. This has usually been the case, and simplifies the problem very considerably, leaving us‡ only three unknown

* A very strong analogy to a galvanic circuit is afforded by the charge and discharge of an electrical battery 'by cascade.' The first jar being connected with the prime conductor of an electrical machine,—a series of jars, where the interior of each successive one is connected with the insulated outer coating of the preceding, furnishes an imitation of a broken circuit connected with a battery. A connection made between the exterior of the last jar in the series and the interior of the first, either through a discharging rod or through the ground, corresponds to an electropœa or *make-circuit*. The difference between the charge of the first and of the last jar represents the resistance to conduction.

† Faraday, Researches, i, §§ 516, 1630.

‡ Walker, Astr. Journ., i, p. 52.

quantities to deal with,—the time of transmission and the induction and pass-times of the main circuit.

The record of the electrotome signal is not so much exposed to accidental disturbance. The moment that the current ceases in the helix, the enclosed iron begins to lose its magnetic condition, and as soon as it has parted with its magnetism sufficiently to allow the tension of the spiral spring to draw off the armature, the local circuit is broken. The outward pass-time has no influence upon the register. The only quantity to be considered is the time elapsing between the cessation of the current in the helix and the loss of magnetism in the iron. This interval is the converse of the induction-time, and might therefore be denominated the *eduction*-time.

The same that has been remarked of the corrections in the case of an electropœa holds true with regard to the propagation of an electrotome through the local circuit, and the eduction-time in its electro-magnet. The local-circuit adjustments being well made and continuing unchanged, and the intensity of the battery remaining constant,—the error from these sources is the same for all electrotomes and electropœas.

The chief source of error lies, then, as will be observed, in the pass-time of the armature of the receiving magnet, and may be totally avoided by using the electrotome signals only,—as it exercises no influence whatever upon these. It is for this reason that I have preferred to use the electrotome readings only, in preference to a mean between them and the electropœas. The pass-time is a very considerable quantity when compared with the small numbers with which we have to deal in these investigations.

The adjustment of the pass to the most convenient value is made by the operator, by means of the screws at I and O (figs. 1 and 2.) The force with which the armature is attracted may be considered as varying nearly in the inverse ratio of the distances,* except when in very close proximity to the magnet. The distance within which it may be allowed to approach the poles of the magnet is limited by the condition that the tension of the spiral spring must be strong enough to withdraw it as soon as possible after the circuit is broken, and yet not so strong as to delay its starting to return, when the circuit is closed again. The pass is then made as short as is practicable, allowing sufficient play to the armature for all the lines and pauses made on the fillet by the graver to be distinct and sharply defined. The following considerations have guided me in making an estimate as to the pass-time in the experiments under discussion.

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* Channing, Davis's Manual of Magnetism, pp. 150–155.

If we assume the intensity of the attraction exerted by the magnet on the armature to be equal to gravity at the earth's surface,—the following numbers give the pass-time for different lengths of the pass.

Length of Pass. Millimeters.	Time. Seconds.	Length of Pass. Millimeters.	Time. Seconds.
2·50	0·0226	1·25	·0160
2·25	·0214	1·00	·0143
2·00	·0202	0·75	·0124
1·75	·0189	0·50	·0105
1·50	·0175	0·25	0·0086

As far as I can judge, the usual pass in the main-circuit *receiving magnet* is between $1^{m \cdot m}75$ and $0^{m \cdot m}50$, which would on our present assumption, give the pass-time $0^{s}019$ and $0^{s}010$. An attractive force four times that of gravity would give the half of these numbers. But this mode of viewing the subject is a very rough one, for as the attraction varies with the distance, the initial force, (which exercises the greatest influence upon the time of passage,) would be much less when the length of pass is greater,—and the tension of the back-spring also operates to increase the pass-time very considerably. I incline to the belief that the average pass-time in the experiments of Feb. 4, was about $0^{s}03$. Mr. Walker, on the contrary, estimates it at $\frac{1}{15}$th of a second—more than twice as much. Had we any means of measuring the absolute duration of the interruption of the circuit by Mr. Saxton's clock, it would be of great service in aiding us to deduce the pass-time in many cases. In all conclusions drawn from the telegraph fillets alone, the pass-time and the induction-time are inseparably combined. Denoting the several intervals by their initials, we have for the length of the *recorded* clock-pause, which we will indicate by a *capital* letter, $C = c - e + i + p$.

As a first hypothesis, we may assume what appears not improbable from other considerations, that e and i are equal. Then subtracting the length of the interval during which the circuit was actually broken by the clock, the remainder would be the *pass-time*. For this purpose I solicited you to request Mr. Saxton to form some estimate, if possible, of the interval between the breaking and closing of the circuit, at each clock-pause. Mr. Saxton expressed himself unable to do this, which is much to be regretted. It had appeared to me that careful observations of the angle with the vertical, made by the pendulum at the time of striking the tilt-hammer, might justify some precision in forming an estimate. The pass-time, thus deduced, would in its turn enable us to examine into the propriety of our hypothesis regarding the equality of the *induction* and *eduction*-times. This is supported at present only by the result, in which I feel some con-

fidence—that the velocity of the electrotome and electropœa signals is the same. The latter is, however, inversely proportional to the sum of all the induction-times of the molecules on the line of wire,—the former to the sum of their eduction-times. If these are equal for the wire, the inference is natural that they are equal for the iron enclosed in the helix, if this be as soft as the iron of the wire.

Such speculations are indeed loose, and would not be warranted, were data within our reach for an accurate investigation of the question. But, as the problem now presents itself to us, everything appears interesting and worthy of consideration, which affords opportunity even for a presumption.

In the apparatus used by my friend Prof. Mitchel, he considers* that he is able actually to measure the length of the armature time, which is the sum of the induction and pass-times. The method which he uses is, however, incapable of being applied to the record made with Morse's instrument.

In an earlier part of my remarks, I deferred the discussion of the question whether the electrotomes and electropœas traveled with the same velocity, and yet have just now expressed the opinion that they did. The opinion was formed as follows:

We have the length of the recorded clock-pause, $C=c-e+i+p$, and of the recorded signal-pause, $S=s-e+i+p$.

If we take the difference of these, the three unknown quantities disappear, and we have $C-S=c-s$, the difference of the real duration of the pauses, equal the difference of their recorded duration. The only assumption here made is that the induction, eduction and pass-times are the same for both pauses,—an assumption quite warrantable if we compare each signal-pause with the clock-pause nearest it. They will then rarely be more than a quarter of a second distant from one another, and the values of the corrections are not likely to change appreciably within so short an interval. I have formed a table of the differences in the length of the same signal and clock-dots, for six different telegraph-stations on the line between Washington and St. Louis, and, from the discussion of more than a hundred different signals, find that the mean of these differences is almost identical for all the stations.

The intensity of the current even at the same place is quite unequal, owing to various influences, among which are thermometric and hygrometric changes in the atmosphere, which affect the insulation and the conduction; want of constancy in the batteries whose activity varies very much with variations of temperature; want of homogeneity in the substance of the plates; the continual formation† and flaking off of coatings of oxyd, and

* Astr. Journ., i, p. 16.

† Faraday, Researches, i, § 1144.

many other circumstances. We have already seen that the pass-time varies with the intensity of the electro-magnetism in the iron and consequently* with the intensity of the current,—and can therefore infer that the different clock pauses would not appear of the same length even on the same registers. That they do not, may be inferred from the following table, which gives the mean value of clock-pauses at each station for each one of five successive minutes.

MEAN LENGTH OF CLOCK-PAUSE.						
	S. S.	W.	P.	C.	L.	St. L.
8h.47	0s·072	0·068	0·055	0·095	0·096	0·092
48	0·091	0·050	0·067	0·090	0·093	0·100
49	0·094	0·065	0·055	0·084	0·125	0·110
50	0·103	0·071	0·059	0·081	0·103	0·118
51	0·100	0·078	0·055	0·081	0·093	0·102
Mean.	0·091	0·067	0·058	0·087	0·104	0·109

It will here be observed that the variations follow no general law whatever, the length of the pause decreasing at one station while it increases at another, and being in no way proportionate to the distance from the clock station, nor, so far as I can judge, to the strength† of the local batteries.

The pass of the Pittsburg register was too small,—so small as to render the register very indistinct and difficult to read, and it will be observed that the clock-pauses are the shortest on the Pittsburg register. The record upon the Cincinnati fillet was the most distinct of all, owing in part, however, to the finer quality of the paper. Clock pauses occur of every length, from 0s·04 to 0s·16. The average length is not far from 0s·086. I believe that the greater part of the irregularities are due to causes much less occult than those we have been considering, and chiefly to irregularities and imperfections in the mechanical part of the registering apparatus.

Bain's galvano-chemical telegraph affords an opportunity of trying the experiment under circumstances totally independent of the pass-time, which has proved so troublesome in the experiments made with Morse's apparatus. The paper on which the record of Bain's telegraph is made, is colored with a solution of ferrocyanate of potash. It rests upon a revolving metallic disc connected with one pole of the battery, while a needle or finely pointed wire connected with the other pole, trails on the upper surface. When the circuit is closed, the current passes between the needle and the metallic disc, coloring the paper in its passage by the partial decomposition of the ferrocyanate. Walker has

* Fechner, Schw. n. Jahrb., ix, pp. 274, 316. Lenz and Jacobi, Pogg. Annalen, xlvii, 233. Bull. de l'Acad. de Pétersburg, vol. iv.

† Pouillet, Comptes Rendus, iv, p. 272.

made a series of experiments with this telegraph between Boston and New York.* But although the pass-time is here avoided, other sources of error are introduced. The times† of delay and of persistence in the chemical action take the place of the induction and the eduction-times in the electro-magnet, and a new and serious difficulty presents itself in the spreading of the lines which have undergone chemical action.

The character of the electro-chemical telegraph allows no local circuit, in the technical sense of this term, and indeed it is unnecessary, for a current capable of closing a local circuit would suffice to act with energy on the very sensitive salt with which the paper is saturated.

But in the experiment for velocity, it is indispensable that a record be kept at the two terminal stations, at least; and the closing of the circuit, in order to record at one station, necessarily diverts the current from the other. With a powerful battery a record may be successfully kept at stations no farther distant than New York and Boston; but if we use a line as long as that between New York and Buffalo, a battery so powerful as to burn a hole through the paper at one terminus, cannot record signals at the other, when the circuit of the signal-station is closed.

Mr. Bain has ingeniously remedied this difficulty by using a short circuit at the signal-station, which is closed by the same key that closes the main circuit. Yet even this introduces still a new source of uncertainty. A curious result which Mr. Walker has deduced‡ from his experiments consists in the fact that the discolored lines, which measure the duration of the current, are longer at the station where the signals are given, than at the other extremity of the line. An inference might be drawn from this, opposed to that which I have drawn from the St. Louis registers, concerning the equality of velocity for the electrotomes and electropœas; but it appears to me more probable that the circumstance is due either to the difference of circuit or to the superior intensity of the current, and consequently, of its chemical action at the signal-station. The question remains open for discussion.

The experiments of Fizeau and Gounelle, in France, described in the *Comptes Rendus* for April last, were made on an entirely different principle, and conducted them to a series of inferences which they give in detail. The published description§ of their method is very obscure, and the data on which their inferences are founded are not fully given. Their method appears to be in some degree, analogous to the very elegant experiment‖

* Ast. Journ., i, p. 105.
† Proc. Am. Assoc., 1849, p. 189. Ast. Journ., i, p. 108.
‡ Ast. Journ., i, p. 106. § Comptes Rendus, xxx, p. 439.
‖ Comptes Rendus, xxix, pp. 90, 132.

by which Mr. Fizeau had previously measured the velocity of light between Paris and Montmartre. A wheel, whose circumference consisted of 36 divisions, alternately of wood and platinum, revolved in contact with the edges of insulated plates of platinum, each pair of plates forming a distinct circuit-breaker. The driving machinery of the wheel was connected with an apparatus for measuring the velocity of rotation; and the effect of different velocities and different circuits was observed upon the galvanometer.*

The velocity of the current, which they deduced from these experiments, was, as I have already mentioned, 63,200 miles per second in iron wire 4 millimeters in diameter, and 110,000 in copper wire, 2½ millimeters in thickness.

They inferred, moreover,

That the two electricities were propagated with the same velocity.†

That the tension of the electricity has no influence on the velocity.

That the velocity does not vary with the section of the conducting material, but only with its nature, and then not in the ratio of the conductive power.

That the discontinuous currents "experience a diffusion, in consequence of which they occupy a space greater at the point of arrival than at the point of departure."

This latter result is in direct opposition to the experiments of Walker with the chemical telegraph, by which, using a method of determination indefinitely less complicated he found the length of duration of the electric currents to be less at the more remote station. According to Fizeau,‡ the electropœa is propagated more rapidly than the electrotome;—according to Walker,§ less rapidly. Fizeau used a circuit 374 miles in length, and Walker one of 250 miles of wire, whose two extremities communicated with the ground about 190 miles apart.

The Coast Survey experiments of Feb. 4, on the line between Washington and St. Louis, 1045 miles distant by the wires, and 742 in a geodetic line, lead me to suppose, as already stated, that the velocity of the two signals is the same, and (other things being equal) the pauses would be of equal length, as recorded at all the stations on the circuit. I am inclined to attribute Walker's results to the more intense chemical action of the current on the prepared paper at the signal stations,—and while entertaining the most profound admiration for the remarkable ingenuity and care shown by Fizeau, I cannot consider his method as capable of giving results worthy of implicit reliance.

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* Becquerel, Traité, v, p. 275.
† Faraday, Res., i, § 1333.
‡ Comptes Rendus, xxx, p. 440.
§ Ast. Journ., i, p. 106.

Walker's conclusions respecting the velocity are by no means inconsistent with Wheatstone's experiment; for the tension of the electricity and the conducting power and size of the wire differ so much in the two cases as to prohibit any comparison. Fizeau's, on the contrary, stand in the directest opposition to it, for he finds that neither the tension of the transmitted electricity, the intensity of the current, nor the size of the conductor, exerts any influence on the velocity; and at the same time makes the velocity through his copper wire to be 110,000 miles a second, while Wheatstone found 288,000 to be the minimum limit of the velocity through the copper wire which he used.

(To be continued.)

ART. VII.—*Reply to Mr. De la Rue's remarks on the Navicula Spencerii contained in the American Journal of Science, Vol. IX, p. 23; with a notice of two new test-objects;* by J. W. BAILEY.

IN consequence of absence from home and long continued illness, I have been compelled to delay my reply to the remarks by Mr. De la Rue upon the subject of the Navicula Spencerii. I trust however that it is not too late for a few words in answer. Mr. De la Rue now admits that the American observers were right in attributing the appearances seen on these shells to rows of prominences, and not to perforations or depressions as stated in Mr. Queckett's Treatise, (p. 440,) and as the larger figure on Plate 9 of that work represents them. As we agree with regard to the structure of these objects, the only remaining points of difference between us are the measurements of the distance between the rows, and the difficulty of the species as a test-object. With regard to the accuracy of my measurements it was impossible for me to judge, as Mr. De la Rue's were not made on the "identical specimens" mounted by me, but on others mounted in London and which might have been large and easy individuals. Fortunately however, the means of comparing our measurements of the same object has been kindly furnished me by Mr. De la Rue himself to whom I am indebted for one of those wonders of art, the Nobert Test plates. This was accompanied by a table giving the measurements of each of the fifteen bands of lines upon the plate, the finest set of lines being 56306 to the English inch. By measuring the coarser bands of this test plate, by the ordinary method, the same as used by Mr. De la Rue, I find that my measurements constantly differ from his, and always in the same direction and amount. As the measurements of the coarser lines is too easy for any error in manipulation, I can only conclude that our scales of comparison,

i. e., our micrometers must differ. My own is an English one divided to $\frac{1}{10000}$ths of an inch. Mr. De la Rue states that his is divided to $\frac{1}{50000}$ths of an inch. Which of the two is the most accurate I cannot now determine, and must leave it to future observation, I will remark however that Mr. Spencer of Canestota in some measurements which he has recently made, obtained results intermediate between those obtained by Mr. De la Rue and myself, making the distance between the transverse rows about $\frac{1}{20000}$ of an inch.

In his remarks, Mr. De la Rue emphatically states that at the time of its arrival in London, the markings on the N. Spencerii shown as lines were not a difficult test for the object-glasses of the London observers.

I leave it for others to reconcile this statement with the quotation which I gave from a letter from a London correspondent, which I will now requote, as follows:—

"The evening I received your package there happened to be a small gathering of our microscopic friends. Your slide with the Navicula Spencerii underwent a long examination. We however could make nothing of it. * * * We had some of the best glasses of Smith, Ross and Powell in our examination, and I am bound to state that at present the result is most unsatisfactory."

It appears from the above that it was not Mr. Marshall's glass alone which in the earlier trials of this test in London failed to resolve it. The fact was that all observers found it a difficult object until they became aware of the great obliquity of light required, and most observers admitted it to be a far more difficult test than any at that time known. Mr. De la Rue appears to be the only one who found no difficulty in his first attempts to see this as a lined object, probably owing to the fact that the difficulties of the problem had been previously solved by his friend, Mr. Marshall, so that in their united observations the proper illumination was at once employed. Mr. De la Rue himself gives evidence that the test is one of some value, for it seems that with all his skill it was only "after working about an hour that the dry specimen was resolved most satisfactorily" as a dotted object.

But I will not dwell upon the subject of the early experience of observers at home and abroad with regard to the test, as it has for some time given place to still more difficult species of lined Naviculæ. I have only wished to relieve myself from the imputation of having "unwillingly overrated" its difficulty. When I claimed that it was worthy of a high place in the list of tests, I was guided by the authority of the best English observers who both in print and in private letters referred to the Navicula Hippocampus as one of the most delicate of lined objects. Finding that the N. Spencerii was far more delicate, and that many glasses failed to resolve it which appeared to perform well upon

the N. Hippocampus, I felt authorized to call the attention of microscopists to it as an object more difficult than any *then* known, by publication, to the scientific world. That rank I still claim for it, but at the same time admit that with proper illumination it may be resolved with ease and certainty by object-glasses of only moderate power made by the English artists, Ross, Powell, Smith, or by our own countryman, Spencer.

To Mr. Spencer I am indebted for the knowledge of two test-objects of far greater difficulty than the N. Spencerii. The first is a species of Grammatophora. The larger species of this genus may be easily made to show sets of prominences producing the appearance of transverse, longitudinal, and even diagonal lines, but the species to which I have applied the name of G. subtilissima has markings of such exceeding tenuity, that I failed to resolve it with one of Spencer's object-glasses, "a sixteenth," made for me about two years ago, although the same glass would readily resolve the N. Spencerii. A new object-glass of admirable workmanship made for me by Mr. Spencer resolves this new test with great ease, as does also a new object-glass ("a twelfth" I believe) made by Ross of London and recently imported by Mr. Cole of Salem. The *G. subtilissima* occurs along our whole coast from Massachusetts to Florida. In form it resembles the G. marina of authors, but is more delicately marked than my European specimens of that species. The specimens with the finest markings I found growing upon the Polysiphonia Olneyii of Harvey, near Providence, R. I.

Another test which is a little more difficult than the last is a species of Navicula sent by Prof. Amici to Mr. Spencer as a test-object which he would probably find sufficiently difficult even when mounted dry. This test Mr. Spencer proposes to call Navicula Amicii, in honor of the distinguished microscopist from whom it was received. It is a small lanceolate freshwater Navicula with exceedingly minute markings which on some specimens appear to me more difficult than even the Providence specimens of the Grammatophora. They however are not beyond the reach of Spencer's new object-glasses which will satisfactorily resolve them even when mounted in balsam. I think that when Mr. De la Rue sees these objects, his doubts "whether the physical properties of light do not put a natural limit to our resolving lines so close as the $\frac{1}{2000}$th and $\frac{1}{3000}$th of an inch" will be removed.

Note.—Since the above was in type, I have been informed by Mr. Spencer, that he considers many of the specimens from Providence as more difficult than any of the specimens of Amici's test. The Grammatophora from Greenport, Long Island, is decidedly easier.

ART. VIII.—*Miscellaneous Notices;* by J. W. BAILEY.

1. *Fossil Infusoria of the Southern Ricefields.*—The earth of the rice fields in Carolina and Georgia is rich in fossil, (marine or estuary,) siliceous Diatomaceæ. They are particularly abundant in the earth freshly excavated in forming the canals and ditches, and hundreds of little shells may be seen with even a common pocket lens, upon the freshly fractured surface of any dry lump of the mud. The species are such as now inhabit the shores and estuaries of the Atlantic states, and which extend much farther up the streams than where the *surface* water is fresh. Among the most common forms are Triceratium favus, Coscinodiscus subtilis, C. excentricus, Gallionella sulcata, Rhaphoneis Rhombus, Terpsinoë musica, Zygoceros Rhombus, &c. The localities examined by me were, on the Ashley river, near Middleton Place; on the Savannah river at Dr. Daniell's plantation, opposite Savannah, and at the deep excavations for ditches, &c., at Fort Jackson; on the Ogeechee at the plantations of R. J. Arnold, Esq., and of Judge Cheves; and on the Altamaha at Hopeton, the classic ground of southern natural history, near the residence of J. Hamilton Couper, Esq. A perfect agreement was found in the character of the fossils at all these localities.

2. *Localities of Terpsinoë musica*, Ehr.—This exquisite siliceous shell whose markings Ehrenberg aptly compares to a double row of musical notes, enclosed in a glass casket, was first discovered by Ehrenberg in deposits brought from Mexico; Kützing states that he has found it adhering to roots of Marchantia from South America, and Ehrenberg has recently stated* that it occurs abundantly in Texas, but adds however, that it has not yet been detected in the older states of the Union. I am happy to be able to state that it is a common and abundant form in our southern rivers. During the last winter I found it in a living state in the waters of the Ashley, Savannah, Ogeechee, and Altamaha; also in great abundance forming long chains on the roots of Pistia stratiotes in the St. Johns, Withlacoochee and Hillsborough rivers in Florida. I have also specimens of it from Jamaica, and a few portions of apparently the same thing, from Mindanao in the Phillipine Islands. It probably inhabits the rivers of all warm regions. It is abundant as a fossil form in the ricefields.

3. *Fossil Infusoria of Maryland.*—The infusorial beds of Virginia and Maryland, have been heretofore traced from Petersburgh, Virginia, to Herring Bay on the Chesapeake in Maryland, and here "the *trail*" was lost; I have had the good fortune to

* Monatsbericht, &c., Berlin, Feb., 1849.

recover it again at Wye, on the eastern shore of Maryland, where the infusorial stratum reappears with all its usual characteristic species.

4. *Silicified Polythalamia in Florida.*—While passing from Pilatka to Tampa Bay, in Florida, I collected at "Piles's New Place," about forty miles west of Pilatka, large masses presenting all the mineralogical characters of flint. These occur in veins in masses of the white Orbitulite limestone which is common throughout this portion of Florida. Much of this flint is sufficiently translucent to be mounted in thin fragments coated with balsam for microscopic examination. By this means I detected in it numerous silicified specimens of Orbitulina, Nummulina, Rotalia, Textilaria, &c. The siliceous arrow heads found in great abundance in Florida, often present a similar character, and are doubtless from the same formations.

5. *Localities of Paludicella articulata*, Allman.—This beautiful Bryozoan polyp appears to be common in the Highlands of New York, I have found it in considerable abundance in all the ponds near West Point, and also in ditches leading from a swamp near the Crows Nest. It occurs attached to various submerged objects, such as growing plants, bits of wood or stone, fallen leaves, &c., over the surface of which it spreads in an irregular branching manner, sending up from each joint a beautiful animal flower, formed of tentacles covered with vibrating cilia. I have kept it by me for weeks and find it a charming object for microscopic study. A figure and description of it may be found in the London Physiological Journal, vol. i, p. 10.

6. *Circulation in Hydrocharis spongiosa.*—This plant grows in almost every wet place in the Southern states, where it is often known by the name of "Colts foot;" I recommend it to southern microscopists as a beautiful object for the study of the circulation. The hairs covering its aquatic roots are as transparent as glass, and afford an admirable display of the currents, and also of revolving cytoblasts.

ART. IX.—*On the time required to raise the Galvanic Current to its maximum in Coiled Conductors, and its importance in Electro-Mechanics;* by Prof. CHAS. G. PAGE, M.D., Washington, D. C.

M. POUILLET communicated to the French Academy in 1837, "that he had established that a circuit of many thousand metres in length, was traversed by the current in a space of time that did not amount to $\frac{1}{700}$ of a second; and that in this very brief instant it was not simply a portion of the electricity that was

manifested in the circuit, but that the entire current passed with all its intensity." Prof. Henry, however, in his valuable paper on electro-dynamic induction, published in 1840, takes the more consistent ground as follows. He remarks that, "rapid as may be the development of the current, it cannot be supposed to assume *per saltum*, its maximum state of quantity; on the contrary, from the general law of continuity, we would infer that it passes through all the intermediate states of quantity, from that of no current, if the expression may be allowed, to one of full development; there are however, considerations of an experimental nature, which would lead us to the same conclusion, and also to the further inference that the decline of the current is not instantaneous." Prof. Henry also inferred that the "time of the subsidence of the current when the circuit is broken by means of a surface of mercury was very small, and did not exceed the ten thousandth part of a second." He also inferred that "when the circuit is broken by a cup of mercury, the rate of the diminution of the current within certain limits remains the same, however the intensity of the electricity or the length of the conductor may be varied."

I have lately made some remarkable experiments with large coils and powerful currents, which fully and most strikingly establish the "gradual rise and subsidence of the current." The results lead to conclusions differing from those of Henry only with respect to the importance of conduction in regard to the rise of the current. I am led to infer that resistance to conduction within ordinary limits in coiled conductors at least may be neglected in the rise of the current as well as its subsidence, and that the time of subsidence is the same as that of the rise of the current, and that both depend upon the force of the induced current. The induced current *ceteris paribus* depends upon the figure, size and construction of the coil, and therefore, the rise and subsidence of the current is governed as to its time, chiefly by the configuration and size of the coil.

The coils used in my experiments are of peculiar construction to be hereafter described, and each presented a circuit of 600 feet in length. Five of these were used in all, and thus gave a total length of 3000 feet. On connecting a powerful Grove's battery with one of these coils, it was evident at once that if the circuit were of short duration, the secondary spark was small, and if the circuit were prolonged by continuance of contact, the secondary spark was proportionally increased in volume and sound. It was not difficult by the aid of a metronome, to time the contact and to ascertain with some accuracy the time required to give the spark its full effect.

On connecting two, three, or more coils with the same battery, the result was much more striking, from the fact that the

maximum effect of the induced current, or the volume and noise of the spark were so much increased, although the time required appeared to be the same. It was only from the great contrast manifested between almost "*no current*," and a full development of a current which produced a secondary spark of nebular form, having an average diameter of three inches. I may remark here that the form of the spark depends entirely upon the manner of breaking the circuit. When the wires are separated slowly the spark is nebular in form, but when they are separated suddenly and carried to a considerable distance apart, the spark is linear or nearly so, and I have obtained it sometimes when a bar of soft iron was inclosed, from *six to eight inches* in length, and I have no doubt that by following out the novel suggestion of my friend, Mr. Lane, viz., to shoot away the connecting wires by a cannon ball, a spark of a foot or more in length, might be obtained. About twelve years ago I noticed in this Journal a nebular spark of nearly one inch in breadth from a powerful magneto-electric machine, and a linear spark of $\frac{3}{4}$th inch in length from the same machine, but do not remember that they excited any special attention at that time. Their very great magnitude in my present experiments, however, renders them objects of intense interest and beauty. When a soft iron bar is inclosed in the coils, the nebular spark is frequently spread out from five to six inches in breadth. But to return to the subject. Measuring the time of the rise and fall of the current by the metronome, it was found to be from $\frac{1}{6}$th to $\frac{1}{5}$th of a second; when the coils were used alone and when a soft iron bar was included, the time was from $\frac{1}{2}$ to $\frac{3}{4}$th of a second.* The presence of the iron bar increases the initial induced current, and thus delays the rise of the battery currents, and the terminal secondary is also increased and thus sustains or prolongs the duration of the battery current.

It is very interesting to close the circuit in the coil surrounding the iron bar, and watch the subsidence of the current in the coil after the battery current has been entirely removed from it. On opening the circuit by separating the ends of the coil, sparks may be seen at any time within half a second.

From these results it is seen that the time of rising and falling of the current is not only appreciable, but that its great duration makes it a very important element to be considered in the operation of electro-mechanical contrivances. Where magnets are to be charged and discharged, the time of the coil and the additional time of the magnet must be considered, and also the inductive effect due to motion. Where the magnet is to be always charged as in my electro-magnetic engine, the time of the coil and the inductive effect of motion are to be considered. By certain con-

* This view of the case I stated in this Journal in 1838.

trivances which will be described at some future time, I have been enabled to obviate mostly the principal difficulty, viz., the time of the coil, or rather to turn it to a practical account, and to this in part is due my recent great success in the application of this power. I have now an engine of nine to ten horse power, the details of which cannot be given here.

I notice that Mr. Hunt in a recent address before the Society of Arts, in London, describes the effect of secondary currents and also the effect of motion in diminishing the power of electro-magnetic engines, and claims that the subject was then for the first time specifically brought forward. In 1838 I prepared a special paper upon this subject, which was published in Silliman's Journal at that time, in which I fully set forth and anticipated all these difficulties, and also shewed by an instrument termed the Magneto-Electric Multiplier, how the secondary current might be used to increase or diminish the motion of a revolving magnet.

The method of determining the time for the rise of the current in my coils by means of the metronome, and the size of the sparks is not to be relied upon for entire accuracy, and I have in contemplation an instrument by which it can be done more perfectly.

Note.—In a recent letter from Dr. Page, he mentions the following experiment with his powerful magnet.—Eds.

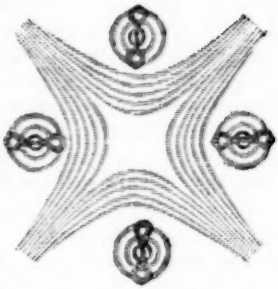
"I have just completed a grand experiment with a huge iron bar and helix, with the following results. *The bar weighing 532 pounds placed within the helix, is made to start up in the coil and vibrate in the air without visible support.* It requires a force of 508 pounds additional to its own weight to pull it out of the helix, so that it is equivalent to lifting a bar in the helix, of 1040 pounds in weight. After this it would seem quite easy to sustain masses of iron weighing many tons. The full time required to charge this magnet and raise the galvanic current to its maximum is two seconds. Nine-tenths of the charge is attained in one second."

Art. X.—*A new figure in Mica and other Phenomena of Polarized Light;* by Prof. Chas. G. Page, M. D., Washington, D. C.

In order to exhibit well the system of rings in mica, we must select the clearest specimens of uniform appearance and density, and the piece should be at least $\frac{1}{20}$th of an inch thick. If the mica be very clear it may be somewhat thicker to advantage. The inclination of the *resultant axes* is so great in mica, that but one of the systems can be seen at once; but by crossing two thick pieces I have found that the two will so compensate as to exhibit in a most beautiful manner the two systems of each piece,

and in addition a charming system of hyperbolas. The pieces, each about $\frac{1}{16}$th of an inch thick, are cemented into frames revolving one within the other, and allowing the mica plates to come very near together without touching. In viewing this figure by polarized light, the Nicols prism is held perpendicular to the mica plates, and not inclined as in viewing a single thickness of mica. Fig. 1 is a representation of this interesting composite system. The colors are brilliant, and the negative figure is not less pleasing than the positive.

1.



Polarization by Caoutchouc and Gutta Percha.—Gutta percha when rolled into thin sheets or drawn into ropes comports itself like a fibrous substance, which is not the case with caoutchouc. A strip cut from a thin sheet of gutta percha may be stretched considerably in one direction, that is, in a line with the fibre, but any attempt to stretch it across this line, is followed at once by a rupture. It is not so with a sheet of caoutchouc, which will stretch equally well in all directions. On examination of thin sheets of these two substances—so far believed to be *isomerical*—a marked difference of texture is at once perceived. The caoutchouc gives little or no change of color, while the gutta percha exhibits a beautiful spectacle. It appears to be built up of prisms of every variety of hue, and as it were fused into each other. It resembles more nearly some specimens of ice which I have examined, than any thing else. The caoutchouc and gutta percha must be kept under considerable tension during the examination.

There is one mode however, in which I have produced some fine figures by means of caoutchouc. The caoutchouc is made into little balloons in the following manner. A very thin sheet is tied over the end of a tube of one half inch bore, and the caoutchouc blown out into a ball and firmly tied just beyond the end of the tube with a piece of silk. The form and size of these balloons are nearly as represented by fig. 2. They can with a little practice be very conveniently made by the mouth. The caoutchouc is drawn over the open mouth and by strong suction it is forced in filling the mouth, when the lips and teeth are compressed over the outer portions, so as to form a neck which is at once twisted up by the fingers and secured with a string. The caoutchouc thus

2.

highly stretched becomes almost transparent, and when viewed by polarized light it gives when in this constrained condition a definite system of colors, not unlike the figures produced in a circular piece of tempered glass.

On a mode of preparing figures for exhibition upon screens by the apparatus of Soleil.—There are no exhibitions within the whole range of optics so fascinating as those with the apparatus of Soleil, in which the various figures, systems of rings and colors by polarized light from crystals, tempered glass and other substances, are thrown upon a large screen in a darkened room. Among the many objects accompanying polarizing apparatus received in this country from Europe, there are usually one or two tasteful diagrams representing a flower, gothic window of stained glass, or some pleasing device. These pieces are prepared at vast labor and expense, and are in reality mosaic work, of thin pieces of selenite cemented to glass by Canada balsam. The selenite is first split into thin laminæ, and each piece examined by polarized light to ascertain its color. The pieces are then assorted according to their thickness, and after being cut into shape according to the character of the diagram or form to be represented, are laid upon glass as before stated. But as each piece will give two distinct complementary colors in one revolution of the eye-piece, they must be carefully examined and cut in reference to their neutral and depolarizing axes in order to a proper disposition of the colors in the figure. From the foregoing it will be readily seen how delicate and difficult is the task to prepare even a small flower in this way. Added to this, the selenite is very fragile and difficult to work, and requires very skillful manipulation. Some of the more elaborate diagrams are very expensive, costing from £15 to £20. Dr. Brewster suggested a mode of making such figures upon selenite, by scratching out the surface, and afterwards polishing it; but this would be more difficult of execution than the mosaic work. It occurred to me that a good effect might be produced by engraving in a peculiar way upon mica, and my first trials about three years since were quite successful and encouraging. The *modus operandi* is as follows: A piece of very clear and uniform mica is selected, about $\frac{1}{50}$th of an inch thick, and this is examined by polarized light to ascertain its color. If the mica splits well we may have the ground-work of almost any color desired, by gradually removing very thin layers and repeating the examination each time. The mica is then laid and secured in place over a drawing or engraving of a bird, flower, butterfly, or any object fancy selects. The whole outline of the figure is then traced upon the mica with a sharp steel point, taking pains to use uniform pressure. The entire film of mica circumscribed by the tracer is then removed by lifting one edge

with a lancet point and stripping it off, and thus we have a new color for the whole figure differing from the ground-work, and we may now proceed to trace all the details, by cutting in to a greater or less depth and detaching the films by the lancet point, and having a polarizing mirror before us and a Nicols prism, we can in a few hours complete a work which will vie in splendor with many of the selenite specimens that occupy many weeks in construction. The pieces when finished are put into frames and are much improved, and protected by being placed between plates of glass with Canada balsam between them. Figs. 3, 4, and 5, are some of the pieces I have executed in this manner, and although not one of them occupied me more than five hours, yet they are truly splendid objects when magnified upon a screen. These illustrations will

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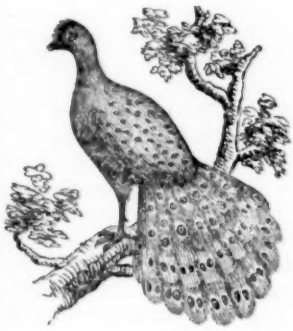

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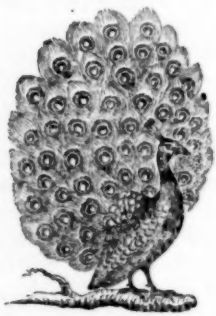

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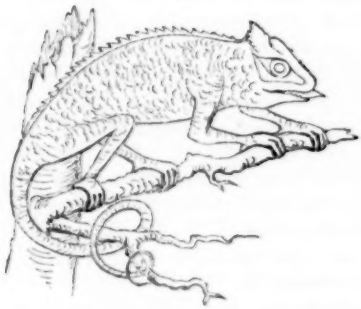


serve as models for any one to work upon, and although seemingly difficult, yet even an unpracticed hand cannot fail to bring out something gratifying. In the figures of the peacock and chameleon, I took the liberty of coloring the trunk of the tree with the brush, which adds much to the picture.

Washington, November 12, 1850.

ART. XI.—*Descriptions of new species of Fungi collected by the U. S. Exploring Expedition under C. Wilkes, U. S. N., Commander;* by Rev. M. J. BERKELEY and Rev. M. A. CURTIS.

AGARICUS (Pleuropus) LAGOTIS, Berk. and Curt.;—pileo sessili elongato-conchiformi, antice latiori; strato superiore gelatinoso setoso-velutino; lamellis subconfertis.—Ad lignum. Oahu, Sandwich Islands.

Cap 1¼ in. long, sessile, narrowed behind, broad in front, the upper surface clothed with dense short soft bristles, at length naked in front. Gills moderately close, tawny when dry, edge entire. Spores white, round-oval.

Allied to *A. atropurpureus*, but differing in the coarse velvety coat which resembles that of *Exidia hispidula*, Berk. It also bears a strong resemblance to *Lentinus pelliculosus*, but the hairs are not fasciculate as in that species, nor are the gills toothed, not to mention the generic difference.

A. (Flammula) CRÆSUS, Berk. and Curt.;—aureus; pileo carnoso excentrico pilis innatis subtiliter squamoso; stipite brevi obeso; lamellis postice emarginatis confertis; sporis minoribus ellipticis.—Ad lignum (pineum?) Waha-rua Bay, New Zealand.

Cap 3 in. broad, sprinkled with obscure appressed pilose scales; stem 7 lines long, 4 thick, paler that the pileus, furfuraceo-tomentose; gills broad, strongly emarginate or sinuated behind, scarcely adnate, of a uniform golden yellow, not spotted.—Closely allied to *A. aureus*, but differing in its short excentric ringless stem and far smaller spores.

LENTINUS WILKESII, Berk. and Curt.;—tener; pileo profunde infundibuliformi subtiliter tomentoso lineato; stipite subæquali sursum furfuraceo deorsum nigro; lamellis confertissimis tenerrimis spiculiferis.—Ad lignum. Feejee Islands.

About 1 in. broad, white, finely streaked, margin slightly incurved; stem 1¼ in. long, scarce 1 line thick, black below, pale and furfuraceous above; gills extremely delicate and close, the edge very finely notched.—Closely resembling *L. pergameneus*, Lev., but more infundibuliform and with much more crowded gills.

POLYPORUS BRUNNEOLUS, Berk., in Lond. Journ. Bot., III, 187;—var. opacus; pileo renato-flabelliformi antice lobato tenui crebri-zonato sulcato opaco subtiliter tomentoso postice hic illic fucato glabro, pallide brunneolo zonis obscurioribus; stipite brevissimo disciformi; hymenio albido; poris minutis punctiformibus, acie integra obtusa.—Ad corticem arboris.—Samoan Group.

There is but a single specimen of this in the collection, which agrees pretty well with one of the original specimens from the Philippine Isles.

P. LITURARIUS, Berk. and Curt. ;—carnosus tenuis ; pileo flabelliformi glabro lineolato ; stipite brevissimo cum pileo postice attenuato confluente ; poris minutis angulatis, dissepimentis tenuissimis denticulatis.—Ad lignum. Feejee Islands.

Cap 1¼ in. broad, 1¼ long, slightly lobed, reddish brown, marked with fine radiating lines, slightly depressed behind where it is confluent with the extremely short though strictly defined stem ; edge slightly incurved ; hymenium probably white.—A very distinct species to which we cannot point out any near ally. *P. Drummondii* is perhaps the nearest. It also resembles *P. sector*, but has no raised lines and is quite smooth.

FAVOLUS PLATYPORUS, Berk. and Curt. ;—pileo reniformi sublobato rigidiusculo glabro e contextu supra dissepimenta contracto reticulato ; poris amplis oblongis subhexagonis, dissepimentis emarginatis rigidis, acie subintegra.—Feejee Islands.

Cap 2½ in. broad, 1½ long, depressed behind, reticulated by the contraction of the substance above the dissepiments, edge very thin and acute. Stem extremely short, disciform. Dissepiments scooped out in the middle, pores 2 lines or more long, 1 line broad, but varying much in size.—Nearly allied to *F. alutaceus*, Mont. and Berk., but differing in its larger pores and reticulated surface. The pores are more rigid than in any other species with which we are acquainted except an undescribed species from Canada, which has not however the reticulated pileus. *F. intestinalis*, Berk., has pores as large, but is totally different in other respects.

THELEPHORA LAMELLATA, Berk. and Curt. ;—tota ochracea ; pileo infundibuliformi lobato rugoso-lamellato subtiliter tomentoso ; stipite elongato velutino-tomentoso ; hymenio sulcato rugoso glabro. Feejee Islands.

Pileus 2 in. broad, 1¼ deep, lobed, subplicate, clothed with permanent appressed down, coarsely lamellate rugose. Stem equal, cylindrical, 1½ in. high, 2 lines thick, densely downy, almost velvety, solid. Hymenium rugose-plicate. The whole is of a beautiful ochre or tan color.

This species is rather larger than *T. caperata*, Berk. and Mont., is more strongly lamellate, has a very different kind of coat, and a long almost velvety stem. It does not appear whether this, like *T. caperata*, grows on wood.

T. SCABRA, Berk. and Curt. ;—albida ; pileo anguste flabellato-diviso furcato-lobato, granulato-scabro ; hymenio striato.—Ad terram ? Feejee Islands.

Pileus 1¼ in. high, main divisions much attenuated below, dilated above and incised, with the lobes incised or furcate, rough with little granular warts. Hymenium smooth, striate.—Closely allied to *T. pallida*, Schwein., but distinguished by its rough pileus, which may, however, prove to be an inconstant character.

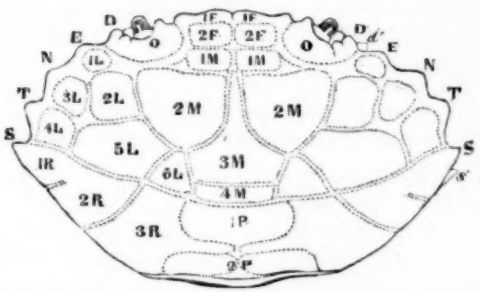
HYPOXYLON PILÆFORME, Berk. and Curt.;—globosum, stipitatum et sessile, piceo-laccatum ostiolis prominulis exasperatum, intus album.—Ad lignum. Oahu.

There are but two specimens of this, one of which is depresso-globose, produced at base into a short rugged stem nearly as long as the head, the whole $\frac{3}{4}$ of an inch high; the other sessile, or with a mere rudiment of a stem, and deformed as if by the partial confluence of two or three heads, thus somewhat resembling a small undulate form of *S. concentrica*.—The species is closely allied to *H. polymorphum*, but the sporidia are shorter and thicker. It resembles also *S. obovata*, Berk., and *S. poculiformis*, Mont.

ART. XII.—*On the markings of the Carapax of Crabs;* by JAMES D. DANA.

THE areas into which the surface of the carapax of Crabs is subdivided were imperfectly distinguished and named by Desmarest. This author designated the regions according to the internal parts which they covered. But there is a system in the markings which this mode of indicating does not express, and moreover there is a uniformity of character and number which it fails to exhibit. Had the uniformity of number, position and outline been generally recognized, the drawings in this department of Crustacea would not be so commonly incorrect; for even figures from high authority usually misrepresent the character of the surface, and few can be pointed to that are faithful sketches. Moreover these regions, correctly understood, indicate certain homologies in the skeleton of the Decapods. We propose at this time simply to describe the surface markings as they appear.

1.



The above figure (fig. 1,) shows the normal number and position as observed in species of the Cancer group. A depression crosses the carapax just back of the middle, and terminates anterior to the last of the normal lateral teeth. Another depression begins in this line either side of the middle and extends

towards the eyes. These depressions divide the carapax into a *medial* region, two *antero-lateral* regions, and a *posterior* region. From the medial, we exclude a frontal portion as a *frontal* region, besides also an *orbital*; and from the posterior two *postero-lateral* regions. Each region has its several subdivisions or areolets.

In the figure referred to, the areolets of the *frontal* region are marked F; of the orbital, O; those of the *medial*, M; those of the *posterior*, P; those of the *antero-lateral*, L; and those of the *postero-lateral*, R;—R being the initial of the last syllable in the word lateral, while L is the initial of the first. The minor subdivisions correspond to prominences or tubercles of the surface and are normally as follows:—

Frontal Region.—1F, the front margin; 2F a prominence just posterior to the front either side of the middle.

Medial Region.—1M, two small anterior prominences, the *præ-medial;* 2M, two large areolets the *extra-medial;* 3M, a central areolet, elongated anteriorly between the areolets 2M, the *intra-medial;* 4M, a transverse areolet just posterior to 3M, the *post-medial.* Two deep punctures usually mark the limit between 3M and 4M, even when there is no depression. 1M is annexed to the medial rather than the frontal region, because it more commonly coalesces with the former, and is a part of it often in general outline.

Antero-lateral Region.—In this region there are normally six areolets and they are often prominent:—1L, near the *first* tooth following the post-orbital. 2L, 3L, posterior to 1L, in a line nearly with the *second* tooth, and 4L, 5L, 6L, between 4M and the *third* tooth.

Postero-lateral Region.—This region on either side consists normally of 3 areolets 1R, 2R, 3R.

Posterior Region.—1P is situated directly behind 4M and is often well circumscribed, and sometimes in shape nearly like 3M reversed and shortened. 2P directly behind 1P, is sometimes simple, but it is more commonly divided in the middle into two areolets. Behind these, is the posterior margin of the carapax.

Orbital Region.—The elevation which encloses the upper side of the orbit is usually divided by sutures into three parts.

The variations in the markings of Crabs arise in the main from the *greater or less prominence of these areolets, their various subdivisions,* or *their obsolescence.* When only a few undulations are apparent on the carapax, a little study with the normal type in view will commonly discover that the system is there although but just apparent; and when once perceived a correct sketch is made without difficulty.

In the *obsolescence* of the areolets, the posterior are the first to disappear, in which case this part of the surface is flat. Next the postero-lateral fail of being distinct. Next 5L and 6L coalesce,

and also 1M and 2M. Next, the posterior of the medial areolets becomes obsolete, and at the same time 5L, 6L disappear, or are indicated only by a slight undulation along the space that ordinarily separates them. The extra-medial may be only circumscribed anteriorly, and the slender elongation of the interno-medial is all that appears of that areolet; next, the remaining antero-lateral areolets may disappear with the frontal, and the surface is then quite smooth. 1L is sometimes indistinct when the other areolets are prominent, though usually it accompanies them.

When 4L, 5L, 6L become indistinct, the transverse depression then prominent instead of passing behind them bends more forward along 3M, and passes anterior to them, and so makes a different subdivision of the carapax in its general aspect and character. In another variety, the prominent transverse depression passes anterior to 5L, but not anterior to 4L, (which may be obsolete,) and has nearly a straight course across the carapax.

In the *subdivision* of the areolets, the first that partake of it are 2M, 5L and 3M. A commencement of this subdivision of 2M (the extra-medial) is very common, and when completed it divides it into two parts longitudinally. This is an important specific character and though hitherto unmentioned in descriptions, it is easily described when a proper notation is adopted. 5L also subdivides from above downward or rather obliquely inward. 3M subdivides at times into 3 parts as shown in figure 2 which includes also 4M. Figure 3 represents another form of this areolet

2. 3. 4.

and 4M. In a still further subdivision, each of the areolets is reduced to tubercles, some of them consisting of but one, and others of three or four. Figure 4 represents the medial region of the *Lagostoma nodosa;* the præmedial is a single tubercle; the extra-medial consists of 7 tubercles, 3 in an inner and 4 in an outer series; the intra-medial includes 4 besides some smaller; and the post-medial includes 2 large and some smaller tubercles. When the subdivisions are not carried as far, a portion may be separated anteriorly from each half of 2M, while the rest remains entire.

It is common for 1R to have a tubercle or two on its surface or areolets in the same transverse line with the tooth.

Teeth of the antero-lateral margin.—The teeth of the margin are normally *five* in number, commencing with the post-orbital as the first. These five are represented in figure 1, and are designated in order by the different letters of the word *dentes* (or *dents* in French) D, E, N, T, S. Each tooth is often separated from the adjoining by a minute suture at the bottom of the indentation between them, and hence the letters always mark rather a lobe of the margin than simply a tooth. These teeth vary by obsolescence or subdivision, like the areolets.

In *obsolescence*, the tooth E (second) is the first to disappear, this reducing the apparent number to *four*. Then N fades out, then T, leaving S alone which may also be wanting. Again S is sometimes smaller than T and even disappears.

In the *multiplication* of teeth, there is often, as a first addition, a tooth s' (or two s', s'',) posterior to S. There is often also a tooth (d') between D and E on a lower level than D. But the multiplication is generally dependent on the subdivision of the normal teeth E, N, T, in addition sometimes to S and D,—each of these teeth consisting of two or three teeth, either all equal or one more prominent. In order to determine the normal relations of the teeth when the number is large, we have a guide in the areolets adjoining when they exist; for the areolet 4L (or the range 6L, 5L, 4L,) terminates against tooth or lobe T, having about the same breadth that belongs to this lobe, the depression anterior to 4L corresponding to the fissure between N and T. So 3L (or 3L, 2L) gives the breadth of the normal tooth or lobe N; and 1L, when present, that of E. We thus find that usually when there are seven teeth anterior to S, each E, N, T, are doubled; when eight E, N are doubled, and either T is trebled, or both T and D are doubled.

The medial and antero-lateral areolets may be viewed relatively in two ways. If we compare the medial region as a whole with either antero-lateral as a whole we find a resemblance in general form and subdivisions. Again we observe that the lobe T, areolets 4L, 5L, 6L, 3M or 4M form a transverse zone across the carapax; again lobe N, areolets 2L, 3L, 2M constitute another transverse zone; and lobe 1L and 1M may be viewed as in another zone. These zones are often very distinctly brought out. The lobes E and N are often a little posterior to the areolets adjoining, —or, the line of the lobe and these areolets has a direction a little obliquely backward of a straight transverse line. Again, when the posterior prominent transverse line passes from the limit between T and S inward, anterior to 5L and not to 4L, as alluded to on the preceding page, the apparent zones are nearly straight transverse.

The medial region in the Cancer group is usually narrower than the breadth measured between the outer angles of the orbits: but in the genus Cancer of *Leach* (*Platycarcinus*, M. Edwards),

it is rather wider, owing to the smaller distance between the eyes. The depression limiting on either side this medial region terminates anteriorly in the line of a fissure in the upper margin of the orbit between 1O and 2O.

It is interesting to trace these regions in other families of the Brachyura; but this we reserve for another occasion. Suffice it to say, that in Atelecyclus, which is broader anteriorly than posteriorly, 3M is much elongated, 1P is as long as broad, and there are the normal teeth with others intermediate. In Calappa in which the posterior part of the carapax is broadest, the medial region is comparatively small, and does not reach back quite to the middle of the carapax. 1P is oblong instead of transverse. In the Maiadæ, the medial region is usually large, while the antero-lateral is very narrow anteriorly. The prominent lateral spine or tooth corresponds to S and is usually far back of the middle of the side or margin, and often in the same line with 1P (*cardiac* region of Desmarest). 4M is often obsolete. The deeper transverse depression, limiting the medial region behind, often, instead of extending outward to a point just exterior to S, (obliquely outward and backward in these Crustacea) extends more forward following the outline of the medial region and then bending outward along the depression between 1L and 2L, 3L, or between 2L, 3L, and 5L, 4L. In the former case the region of the tooth E is anterior to the suture or depression, and in the latter, the regions of both E and N. Traces of the depression separating the antero-lateral and postero-lateral regions are also often apparent in this group.

ART. XIII.—*Chemical examination of a Phosphate of Iron, Manganese, and Lithia, from Norwich, Massachusetts;* by W. J. CRAW, of the Yale Analytical Laboratory.

THIS mineral from Norwich, afforded me the following blowpipe characters. Fuses easily in the blowpipe flame with intumescence to a dark bead, feebly magnetic. Dissolves in large quantity in borax yielding a yellowish-red bead, changing after a while to green. On platinum foil with soda gives the reaction for manganese.

The following are the results of two analyses.

	$\dot{P}$	$\dot{F}e$	$\dot{M}n$	$\dot{A}l$	$\dot{L}i$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$		
1.	41·35	27·36	24·70	*trace*	2·27	1·97	*trace*	2·07,	insoluble	0·29=100·01.
2.	44·64	26·02	23·30	*trace*	2·20	1·61	*trace*	2·07	"	0·30=100·14.
Oxygen ratio for No. 2,	25·02	7·80	7·07		1·21	0·46				

The specific gravity of the crystal analyzed was 2·876, dried at 212 F.

The manganese was found to be in the state of a peroxyd. The iron was also proved to be mostly if not wholly in the same state of oxydation, and I judge from the condition of the manganese that it was wholly so.

From the second analysis we have as the oxygen ratio for the protoxyds, peroxyds and phosphoric acid, 1·67 : 14·87 : 25·02, equivalent closely to 1 : 9 : 15, corresponding to $1\dot{R}, 3\ddot{R}, 3\dot{P}$. Supposing the protoxyds absent we have the simple formula $\ddot{R}\dot{P}$. But including the protoxyds which are beyond doubt essential to the species, we can propose no satisfactory formula.

It is possible that the mineral may have undergone alteration by a peroxydation of some or all of the iron or manganese, as happens with other phosphates of these metals; but on this point we cannot be fully assured without farther exploration at the locality. On the supposition that all the metals were originally protoxyds, and have undergone peroxydation, and that the mineral has not lost any essential part of its bases by infiltrating waters, it would afford the oxygen ratio for protoxyds and phosphoric acid, 11·86 : 25·02, or nearly 1 : 2, which would edge this formula $\dot{R}^3\dot{P}^2$. But in the present state of our knowl- give the formula is altogether hypothetical. In the first analysis, a small proportion of phosphoric acid was not separated from the iron.

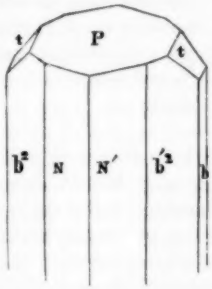
Although the species appears to be near Triphyline, the results tend to prove a wide difference from that species rather than an identity with it.

ART. XIV.—*On the Physical and Crystallographic characters of the Phosphate of Iron, Manganese and Lithia, of Norwich, Massachusetts;* by JAMES D. DANA.

THE phosphate of iron, manganese and lithia of Norwich, analyzed by Mr. Craw, occurs in crystals imbedded in quartz along with the crystallized spodumene of that locality; a massive variety has not been observed. The crystals have an iron-black color, and are wholly opaque; hardness 5–5·5; streak brownish-red. They are rather stout prisms, varying from a fourth of an inch or smaller to over an inch in diameter, and often they are regularly terminated at both extremities. The faces are smooth with in general but little lustre, yet somewhat shining. Cleavage imperfect; basal sometimes distinct; also traces parallel to one lateral plane have been observed. The close approximation in the

angle of the prism to that of Staurotide led to the supposition at first that the mineral was a black variety of that species.*

The accompanying figure exhibits the occurring planes. The form is normally a right prism; yet in very many of the crystals the terminal plane is oblique to the lateral, and this obliquity although an irregularity, is not attended with any distortion of the adjoining plane *t*, the upper and lower edges of this plane being parallel notwithstanding the varying inclination of P. The planes N and N′, are similar in lustre, yet according to the various measurements they are unequally inclined to the plane *b*, which fact, if sustained by a farther examination of crystals, would make the form a *rhomboidal* instead of *rhombic* prism and the system of crystallization *monoclinic*. The doubt which remains arises from the variations in the angles among the crystals, a variation which is certainly surprising considering their seeming perfection. As the crystals are wholly imbedded in quartz, the oblique form was the original form, and it was assumed without the assistance of pressure from other crystals, the quartz being massive. The following are the results of the measurement of ten crystals with the common goniometer.



	I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	X.
N : N′ =	128°	131–132°	127–130½°	30½°	126°	134°	128°	130°	130°	° ′
N : b² =	—	———	113	113	—	108	108	———	———	———
N′ : b² =	—	121½–122	———	———	—	120	115	120–121	118–119	120 12
P : t =	—	131	129–132	———	—	—	—	———	———	———
N : t =	—	101½–102	———	———	—	—	—	———	———	———
N′ : t =	—	113½	110	110–112	—	—	—	———	———	———
N (or N′ ?) : b²	159	162	———	———	—	—	—	———	———	———
P on edge N : N′	?	94–97		90		93	100		90	———
	?	86–87	86		86		80	82–83		———

Several smaller crystals afforded for the last angle 90°, leaving little doubt that this is the true angle notwithstanding the discrepancies. The angle of the prism, (N : N′) averages 130°.

Owing to the singular variations of angle exhibited, it is evident that many more crystals must be examined, before their character is fully understood. The angle of the prism approaches that given for triphyline, 132°; but this angle for triphyline was obtained from cleavage planes, and no such cleavages have been distinctly made out in this species. Its peculiarities suggest that the mineral is a new one; but so many species have already been made from altered triphylines that we forbear naming it until farther investigations have been made.

* See this Journal, [2], x, 121; and also measurements by Mr. Hartwell who obtained with Mr. E. Hitchcock, Jr., the first specimens, same volume, page 265.

ART. XV.—*Notice of the discovery by Walter Mantell, Esq., of Wellington, in the Middle Island of New Zealand, of a living specimen of* NOTORNIS, *a bird of the Rail Family, allied to Brachypteryx, and hitherto known to naturalists only by its fossil remains.* (In a letter from Dr. MANTELL to the Senior Editor.)

I AM sure you will be gratified to learn that the perseverance of my son, Mr. Walter Mantell, now of New Zealand, has been rewarded by the discovery of a living specimen of a genus of *Rallidæ*, of which, crania with the humerus, sternum, and other parts of the skeleton, were found by him associated with remains of the colossal Moas, in the sand deposits near Waingongoro, on the western shores of the North Island. The fossil bird was referred by Professor Owen to a new genus, which he named *Notornis*, (Southern bird), with the specific title *Mantelli*, in commemoration of the discoverer, (see Zoological Transactions, vol. iii.) Now there was a traditional story rife among the natives, that contemporaneously with the gigantic birds, (Dinornis, Palapteryx,) there existed several small birds of various kinds; and a species of *Swamp-hen* was particularized as having been abundant down to a late period, but was supposed to have been long extinct, its extermination being attributed to the wild cats and dogs, which at the present time are a pest to the colonists, destroying the young poultry and other domestic birds, as well as the indigenous species. This rail was said to be of the size of a small turkey, of a black color, without wings, with red beak and legs: no specimen had been seen or heard of since the English colonized the Island. The South Islanders called the bird "*Takahé*," the North Islanders "*Moho*." On a second visit to the southern parts of the Middle Island, my son obtained from some sealers a fine example of the supposed extinct *Notornis*. It appears that these men when frequenting the coasts of Dusky May, (on the S. W. extremity of the Middle Island), in search of seals and other game, perceived on the snow, which thickly covered the ground, the track of a large and strange bird, which they followed a considerable distance, and at length caught sight of the object of their search, which fled with great rapidity from the pursuit of their dogs, and was driven up a gully in a sound behind Resolution Island, and caught alive. It screamed loudly and fought and resisted fiercely upon being captured. It was kept alive a few days on board the schooner, and then killed and roasted, the skin with the head and legs only being preserved. This was fortunately obtained while fresh and in good condition by my son, and thus, perhaps, the last of the race—not of *Mohicans*, but of *Mohos*—was preserved for the naturalists of Europe.

This beautiful bird is about two feet high, and much resembles in its general form the *Porphyrio melanotus*, but is generically distinct; the characters predicated by Professor Owen from the fossil skull and bones, being well exhibited in this recent example. The beak is short and strong, and was, as well as the legs, when this animal was alive, of a bright red color. The neck and body are of a dark purple, the wings and back being shot with green and gold. The wings are short and rounded, and remarkably feeble, both in structure and plumage. The tail is very scanty, and white beneath. Mr. Gould, an eminent ornithologist, (author of the Birds of Australia, &c.), to whom I have given the privilege of figuring and describing it, as a tribute of respect for his indefatigable and beautiful researches in that department of natural history, confirms the opinion that it is identical with the fossil: this, then, is a recent example of the *Notornis Mantelli*, a bird coëval with those marvelous bipeds—those giants of their class—whose stupendous proportions and mighty strength are celebrated in the songs and traditional tales of the New Zealanders, and whose bones and even eggs have been transmitted to Europe, and excited the wonder and delight of the philosophers and the multitude.

In a letter announcing this discovery, my son writes, that he had sent me both recent and fossil specimens of "*a genus of bird hitherto unknown to naturalists*," and though he had not found "a live Moa, he had at least found a living contemporary." It is possible that another specimen of Moho may be caught, sooner or later, yet from all I can gather from persons who have long resided in various parts of the New Zealand Islands, there is greater probability that this may be the last ever seen alive. My son also sent me other fine skins; one of that marvelous New Zealand bird, the *Strigops*—which blends the characters of the owl and parrot, two of *Neomorpha*, and one of *Apteryx australis*, and *Ap. Oweni:* the last is of great rarity; I believe this is but the third specimen sent to England. I shall let the British Museum have it, as there is no example of this species in our national collections. The *Notornis* and the other birds I shall retain.

You will at once perceive the importance of this discovery in its bearing on the problem as to the contemporaneity of the Moa and its kindred with species of which there are still living representatives; it confirms those general inferences as to the probable age of the ossiferous deposits of New Zealand, cited in my Memoirs published in the Geological Journal, and Pictorial Atlas, and also in the lecture delivered in Edinburgh, before the British Association of Science. My son, at the date of his last letter, (May, 1850,) was about to depart once more for the bone-beds on the western shores of the North Island, and with the especial object of exploring certain caverns in the limestone rocks of that

district, which are said to contain bones of Moas and other animals.

A friend of mine lately received a letter, dated October, 1849, from Dr. Thompson, surgeon of the 58th regiment, now at Auckland, in which the writer states that having heard from —— Servantes, the native interpreter, of caves containing birds' bones, he accompanied the latter in search of the place, and was rewarded by obtaining several skulls and mandibles. He observes: "The beak is not like the *Keivi*, (Apteryx), but resembles that of the ostrich or Cassowary. The cave is on the west side of the North Island, in the limestone formation which extends along the coast. The country around is wild, and there are many similar caverns which we were told had birds' bones in them. The popular opinion among the natives is, that the country was once set on fire by an eruption from the volcano of Tongariro, and that all the Moas fled to the caves for refuge, and there perished. This story will do well for the North Island; but how were they extinguished in the Middle Island, where there are no active volcanoes?" In reference to this remark of Dr. Thompson, it is however not a little curious that the tradition of extensive conflagrations over the Middle Island, is confirmed by the state of the subsoil; for my son found that the now grassy plains, where our modern "Canterbury Pilgrims" have fixed their tents, bore evidence beneath the turf of former forests that had been consumed by fire, the charred stumps of the trees remaining in situ. Even on the swamp or morass at Waikonaiti, where my son obtained the remarkable pair of perfect feet, there were traces of the same catastrophe; everywhere, he says, there were charred stumps of trees which had been burnt down to the ground. But it was beneath this superficial covering that the bones of the Moas were entombed; a forest had grown over the ancient swamp, and has been consumed by a conflagration of comparatively recent date; and now the sea covers the site except at low water. I see that a paper by Prof. Owen, on skulls of the *Palapteryx ingens*, is announced for the first meeting of the Zoological Society; I think it probable that these are the specimens collected by Dr. Thompson, and presented to the Governor, Sir George Grey. I intend sending a brief notice of the discovery of the Notornis, to the Zoological Society, as the subject was first announced in the transactions of that body. I may also add that among the fossil shells collected by Mr. Walter Mantell, in the North Island, are species of *Cucullæa*, one apparently identical with *Cucullæa decussata* of England.

My recent acquisitions have not, however, been confined to Antipodean varieties. From the Wealden and my own geological domain, as well as my native soil, I have obtained some highly interesting and novel remains of the colossal reptiles that

were contemporaries of the Iguanodon: of these I hope to give a full and detailed account ere long. I have too at last discovered abundance of fossil cones, the fruit or seed vessels of the fir-trees composing the forests of the Wealden, and of which, as you will remember, Brook Point in the Isle of Wight, affords a notable illustration. I have also a beautiful fossil palm-leaf from the tertiary strata of the Isle of Wight, being the first species of this kind found in England.

Chester Square, Pimlico, November 8, 1850.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

[Note.—It is my intention in future to prepare for the columns of this Journal abstracts of the more important physical and chemical memoirs contained in foreign scientific journals, accompanied by references, and by such critical observations as the occasion may demand. Contributions of a similar character from others will of course not be excluded by this arrangement, but I shall hold myself responsible only for those notices which appear over my initials.

New York, Jan. 1st, 1851. Wolcott Gibbs.]

1. *On the penetration of Magnetism into soft iron;* by Dr. von Feilitzch in Greiswald.*—The researches of Lenz and Jacobi† on the magnetization of soft iron appeared to have demonstrated, 1st, that in massive iron cylinders of equal length and of more than one-third of an inch in diameter, the intensity of magnetism produced by currents of equal force and traversing spirals of an equal number of windings, is proportional to the diameters of the cylinders; and 2d, that the magnetism induced in soft iron by galvanic currents is proportional to the force of the inducing current. From the first of these laws it would follow that the magnetic tension of the iron would exist only upon its surface, and would not penetrate the interior of the mass; the second law would exclude the existence of a point of saturation or of maximum magnetic intensity. These considerations induced the author to investigate the subject anew, and the results of his observations are contained in the memoir before us. The force of the current used was in each case measured by a method described by the author in a former memoir,‡ the principle of which consists in equilibrating the deflecting force of the current upon a magnetic needle by means of a permanent magnet, the magnetic intensity of which has been previously referred to absolute measure. The needle is placed upon the middle of a scale at right angles to the magnetic meridian, the center of the needle forming the 0 point of the scale. A helix of copper wire the length of which is represented by $2a$, (102^{mm}), is placed upon one side of the needle,

* Pogg. Ann. lxxx, 321. † do. xlvii, 225. ‡ do. lxxviii, 21.

the magnetic bar whose length is $2a$, ($91{\cdot}0^{mm}$), upon the other. The helix traversed by the current and the bar may be slid upon the scale till the sum of their deflecting actions upon the needle is **0**; the distances of their centres, r and ϱ, from the 0 of the scale may then be read off, and the magnetic force J^1 of the spiral or of a soft iron bar in its axis, determined by the formula

$$J^1\left(\frac{1}{(r-a)_2}-\frac{1}{(r+a)^2}\right)=J\left(\frac{1}{(\varrho-a)^2}-\frac{1}{(\varrho+a)^2}\right)$$

where J, which in comparative experiments may be regarded as $=1$ represents the quantity of magnetism in the steel bar. The author first determined the force of the current alone, then introduced a bar of soft iron or an iron cylinder into the axis of the spiral and measured the intensity of the induced magnetism, directing the two ends of the bar alternately toward the 0 point of the scale, the difference between the magnetic intensity of the spiral alone and that of the spiral and iron core together, gave the magnetic intensity of the core. A number of hollow iron cylinders, fitting closely into each other, were prepared, and by means of these and the method of measurement already described, the author arrived at the following conclusions:

(1.) Electro-magnetism penetrates into the interior of soft iron.

(2.) The more powerful the inducing current the deeper the penetration.

(3.) Every layer of the soft iron has a point of saturation.

(4.) The magnetism of hollow and massive cylinders of the same kind of iron is of equal intensity, provided that there be a sufficient mass of iron present for its evolution.

And furthermore that

"The density of the electro-magnetism upon the surface of soft iron is the same for all currents whatever may be their force, and may be expressed by the number 7·200."

[The researches above mentioned would appear to lead to the conclusion that every bar of iron magnetized by induction must have a point of saturation, at which the magnetism of every layer in the substance of the bar would equal that upon the surface, yet it is probable that this point of saturation could never be attained by any force of current which we are able to command, at least in the case of bars of any considerable diameter.]

2. *On the law for the intensity of Magnetism induced in soft iron by galvanic currents.*—BUFF and ZAMMINER have undertaken an experimental investigation of the law of Lenz and Jacobi, that the intensity of the magnetism induced in soft iron by galvanic currents is proportional to the force of the current. Müller in Freiberg has recently called this law in question, and asserts, that for every bar there is a point of saturation beyond which the intensity of the magnetism is not increased. The method of investigation pursued by the authors is the same as that used by Müller and in an earlier and unpublished series of experiments by Buff. The current passes through the ring of a tangent compass and through a magnetizing spiral or helix, into the axis of which iron cores of different dimensions may be inserted. A small magnetic needle is placed horizontally in such a position that the axis of the iron core

when produced and at right angles to the meridian passes through the center of the needle. The force of the current is varied by means of a Wheatstone's rheostat which forms part of the circuit. If φ and φ' represent the angular deviations of the two magnetic needles, then for the same series of experiments $\frac{\tan \varphi}{\tan \varphi'}$ must be constant in case the assumed proportionality between the intensities of the inducing current and of the induced magnetism, holds good. The iron bars employed were cylindrical, and their surfaces were turned smooth to remove the layer hardened by hammering. The results of numerous careful determinations show that the ratio $\frac{\tan \varphi}{\tan \varphi'}$ is *ceteris paribus* constant, and consequently confirm the law of Lenz and Jacobi. [The authors attribute the opposite results obtained by Müller partly to the manner in which the investigation was made, and partly to the want of softness in the iron employed, a portion of magnetism being always retained, which Müller does not appear to have sufficiently guarded against by interrupting and reversing the current. Nevertheless the experiments of von Feilitzch yield some support to Müller's view, and certainly render a thorough investigation of the whole subject desirable.]

3. *On the action of heat and alkaline bases upon the homologues of Acetic Acid.*—Cahours has studied the products of the simultaneous action of heat and alkaline bases upon the homologues of acetic acid. Pelargonic acid $C_{18}H_{18}O_4$, was distilled with four times its weight of potash-lime. A limpid amber colored liquid was obtained, together with a considerable quantity of gas possessing a high illuminating power, and there remained in the retort a mixture of caustic alkali and of alkaline carbonates. The gas obtained was passed through bromine which absorbed a large proportion, the part which escaped possessed but a feeble power of illumination when compared with that of the raw product. The brominated liquid was found to contain three distinct products in variable proportions:

$C_4H_4Br_2$=4 vol. vapor boiling at 130° C.
$C_6B_6Br_2$=4 vol. vapor boiling at 144° C.
$C_8H_8Br_2$=4 vol. vapor boiling at 160° C.

The gas absorbed consists therefore of olefiant gas, (acetene), propylene C_6H_6, and butyrene C_8H_8; the unabsorbed portion consisted of hydrogen and marsh gas (palene). The liquid condensed began to boil at 105° to 106°, the last portions distilled between 135° and 140°; the portion boiling between 106° and 110° possessed a density of 0·708, at 16°, the density of its vapor was 3·954, which leads to the formula $C_{16}H_{16}$=4 vol. vapor. With bromine this liquid gave a heavy fluid compound, $C_{16}H_{16}Br_2$=4 vol. vapor, which is therefore a homologue of the preceding. The author has obtained similar results with caprylic, enanthylic, margaric and ethalic acids; all of these gave liquid carburets of hydrogen of the form $C_m H_m$ as well as the gases C_4H_4, C_6H_6, C_8H_8. After recalling the analogous results obtained by Hofmann with valeric acid, the author concludes, that setting out with valeric acid the homologues of marsh gas (palene) do not possess

sufficient stability to resist the temperature at which the decomposition of the acid takes place, and that they are therefore resolved into marsh gas, hydrogen, and a series of hydro-carburets of the form $C_m H_m$.—*Comptes Rendus, July 29th*, 1850.

4. *On the products of the action of chlorine upon Propylene.*—Cahours has also examined the products of the action of chlorine upon propylene, C_6H_6. When chlorine and the gas obtained as above by the decomposition of pelargonic acid are caused to meet in a large receiver, white vapors are seen, and a liquid condenses upon the walls of the receiver which contains as its chief constituent a compound analogous to the liquor of the Dutch chemists ($C_4H_4Cl_2$) and represented by the formula $C_6H_6Cl_2$. This liquid, the discovery of which is due to Reynolds, furnishes the starting point of the author's investigations. Submitted to the action of a current of chlorine a series of liquids is obtained, represented by the following formulæ:

$C_6H_6Cl_2$	boiling at	104°	Density	=1·151=4	vol. vapor.
$C_6H_5Cl_3$	"	170°	"	=1·347=4	" "
$C_6H_4Cl_4$	"	195°–200°	"	=1·548=4	" "
$C_6H_3Cl_5$	"	220°–225°	"	=1·548=4	" "
$C_6H_2Cl_6$	"	240°–245°	"	=1·626=4	" "
C_6HCl_7	"	260°	"	=1·731=4	" "
C_6Cl_8	"	280°	"	=1·860=4	" "

These compounds distilled with an alcoholic solution of potash yield a new series of homologues with those derived in a similar manner from the liquor of the Dutch chemists and its derivatives by substitution. We thus obtain the compounds C_6H_5Cl, $C_6H_4Cl_2$, $C_6H_3Cl_3$, $C_6H_2Cl_4$, C_6HCl_5, C_6Cl_6, each of which corresponds to 4 vols. vapor. By similar processes, M. Cahours has obtained several members of the two corresponding bromine series, viz.: $C_6H_6Br_2$, $C_6H_5Br_3$, $C_6H_4Br_4$, $C_6H_3Br_5$, and C_6H_5Br, $C_6H_4Br_2$, $C_6H_3Br_3$. The readiness with which these last series are obtained led the author to examine the products of the successive action of bromine and of an alcoholic solution of potash upon the brominated Dutch liquor $C_4H_4Br_2$; bromine compounds corresponding to the two chlorids C_4Cl_4 and C_4Cl_6 could not be obtained, but the two series following were procured in the manner stated. $C_4H_4Br_2$, $C_4H_3Br_3$, $C_4H_2Br_4$, C_4HBr_5 and C_4H_3Br, $C_4H_2Br_2$, C_4HBr_3. Similar compounds were produced by the action of bromine upon other hydro-carburets of the series $C_m H_m$, as for instance, butyrene, anilene, paramilene, &c.—*Comptes Rendus, August 26th*, 1850.

5. *On the combinations of Iodine and Phosphorus.*—Corenwinder has succeeded in preparing definite and crystalline combinations of iodine and phosphorus by successively dissolving the two substances in sulphuret of carbon, and cooling the solution artificially. Two eq. of iodine and one eq. of phosphorus give large orange-red prismatic crystals of an iodid, represented by the formula PhI_2; this compound fuses at about 110°, changes in the air, and volatilizes at a higher temperature. Three eq. of iodine and one eq. of phosphorus yield large irregular crystals of a fine red color, and apparently consisting of hexagonal plates; these crystals by distillation give a mass capable of

crystallizing by fusion in very long prisms. The iodid PhI_3 fuses at 55° C. and is decomposed by water with evolution of H I. When five eq. of iodine and two of phosphorus are employed, we obtain at first crystals of PhI_2, and then those of PhI_3. By using the sulphuret of carbon as a solvent, the author obtained in crystals many other compounds, such as the perchlorid and the sulphuret of phosphorus.—*Comptes Rendus, August 5th*, 1850.

6. *Preparation of Chlorate of Potash.*—Calvert has given a new mode of preparing chlorate of potash which offers great advantages over those now in use. One equivalent of caustic potash is to be dissolved in so much water that the solution has a density of 1·110; six equivalents of quicklime are to be added, and the whole gradually heated to 50° C. A rapid current of chlorine is then to be passed through the solution till it becomes saturated, the chemical action raising the temperature to 90°; the liquid is to be filtered, evaporated to dryness, the residue dissolved in boiling water, and the solution allowed to cool, when the chlorate is obtained in crystals.—*Comptes Rendus*, xxx, 656.

[The employment of quicklime in connection with potash was first suggested by Graham; the two substances were however mixed when dry, and the process is believed to have been unsuccessful upon the large scale.]

7. *Iodine.*—Bussy has discovered iodine, and Mène bromine, in the ammoniacal liquids obtained in the manufacture of gas.—*Comptes Rendus*, xxx, 612, 537.

Lamy, Meyse, Chatin and Personne have found iodine in various fresh water plants, in Confervæ, and in the ashes of the beet root.—*Comptes Rendus*, xxx, 463, 478, 475.

8. *Absorption of carbonic oxyd by an ammoniacal solution of subchlorid of copper.*—Stas, Doyère and Leblanc had observed the absorption of carbonic oxyd by an ammoniacal solution of subchlorid of copper. Leblanc has studied the subject more particularly, and obtained the following results. A solution of subchlorid of copper in chlorohydric acid absorbs oxyd of carbon rapidly, and in considerable quantity, though with but slight elevation of temperature. The ammoniacal subchlorid absorbs the gas in the same manner, and the quantity absorbed is the same for the same quantity of copper dissolved. The acid solution of the subchlorid, after being saturated with the gas, may be diluted with water without precipitation and without evolution of gas. Other salts of the suboxyd of copper were found to absorb the gas in a similar manner; ebullition and a complete vacuum expel the oxyd of carbon, but the author did not succeed in obtaining an isolated compound, though the quantity of the gas absorbed by a cupreous solution appeared to be one eq. for one eq. of copper dissolved. The analogy between this reaction and the absorption of nitric oxyd by protosalts of iron is obvious; salts of iron and tin, however, were found to have no action on the oxyd of carbon.—*Comptes Rendus*, xxx, 483.

9. *On the coloring principles of Madder.*—Wolff and Strecker have contributed a memoir on the coloring principles of Madder which offers many new points of interest. A careful study of the madder itself as well as comparative experiments on materials prepared by Robiquet, Schunck, and Debus, led them to admit the existence in

madder of two red coloring principles, viz.: alizarin and purpurin, and of yellow or orange substances which perform no important part in the operation of the dyer. Alizarin, as prepared by a new process resembling that of Schunck, but for which we must refer to the original paper, presents itself in two different forms, viz., as hydrous and as anhydrous. The hydrated alizarin is obtained in scales which resemble aurum musivum; the anhydrous exhibits a red color, with a more or less distinct yellow tinge, according to the thickness of the crystals. On heating it fuses and sublimes in orange-colored needles, a small portion at the same time undergoing decomposition. It is with difficulty moistened by cold water, but dissolves in boiling water with a deep yellow color. The smallest trace of alkali colors the solution red. It is soluble in alcohol and ether; the alcoholic solution is reddened by alkalies, the etherial on the contrary remains unchanged, as the red alkaline compound is insoluble in this medium. Alkalies readily dissolve alizarin; the solution in caustic soda or potash when moderately concentrated is red by transmitted and blue by reflected light; by dilution the liquid assumes a uniform violet tint. In alkaline carbonates, alizarin is soluble with a color resembling that of litmus, but without a blue reflection. The authors refer the differences in color of these solutions to the formation of different combinations of alizarin and alkali. Schunck represented the constitution of alizarin by the formula $C_{14}H_5O_4$; Debus by $C_{30}H_{10}O_9$; the authors propose the formula $C_{20}H_6O_6$, and show that it accurately corresponds with the analytical results of both Schunck and Debus. The hydrate of alizarin is represented by $C_{14}H_5O_4+4HO$. The following table represents the constitution of the principal compounds of alizarin:

Alizarin, oxyd of lead,	$2(C_{20}H_5O_5)+3PbO$	(Schunck.)
Alizarin, oxyd of lead,	$3(C_{20}H_5O_5)+4PbO$	(Debus.)
Alizarin-lime,	$2(C_{20}H_6O_6)+3CaO+3$ aq.	
Alizarin-baryta,	$C_{20}H_6O_6+2BaO$	
" "	$2(C_{20}H_6O_6)+3BaO+3$ aq.	
" "	$3(C_{20}H_6O_6)+2BaO$	

By the action of different oxydizing agents upon alizarin, an acid is obtained which was described by Schunck under the name of alizaric acid. Laurent and Gerhardt pointed out the resemblance between alizaric and phthalic acid, and asserted the identity of these acids. Wolff and Strecker have placed the identity of the two acids beyond a doubt, and represent the conversion of alizaric into phthalic acid by the equation.

$$\overbrace{C_{20}H_6O_6}^{\text{Alizaric acid.}}+2HO+O_8=\overbrace{C_{16}H_6O_8}^{\text{Phthalic acid.}}+\overbrace{C_4H_2O_8}^{\text{Oxalic acid.}}.$$

They further demonstrate that the chloro-naphthalic acid of Laurent is identical with chlorinated alizarin, as may be seen by the following formula.

Alizarin,	$C_{20}H_6O_6$.
Chloro-naphthalic acid,	$C_{20}H_5\left\{\begin{matrix}\\ Cl\end{matrix}\right\}O_6$.

Laurent long since showed that chloro-naphthalic acid by oxydation yields phthalic, oxalic, and chlorohydric acids. The authors however, did not perfectly succeed in transforming chloro-naphthalic into alizarin, either by Melsen's or by Kolbe's method of replacing chlorine by hydrogen; they invite the attention of other chemists to the subject, and point out the practical advantage which would accrue from a method of converting naphthalin into alizarin.

Purpurin crystallizes from its solution in *strong* alcohol in red needles; from weak alcohol on the contrary, in fine, soft, orange-colored needles, which dry to a felted mass. The orange-colored needles contain water which they lose at 100°. Purpurin is more easily soluble in water than alizarin, and with a redder color. It fuses by heating and sublimes leaving some carbon; its solution in caustic potash is cherry red without the blue reflection characteristic of alizarin. The authors propose for purpurin the formula $C_{18}H_6O_6$, in place of that of Debus $C_{15}H_5O_5$. The hydrate has the formula $C_{18}H_6O_6+HO$. Purpurin contains therefore 2 eqs. less of carbon than alizarin and it is highly probable that the latter may be converted into the former by oxydation. As shown by the equation,

$$C_{18}H_6O_6+HO+O_5=C_{16}H_6O_8+C_2HO_4.$$

Purpurin with nitric acid yields phthalic and oxalic acids.—*Annalen der Chemie und Pharmacie*, lxxv, 1, *July*, 1850.

10. *Action of Sulphite of Ammonia.*—Piria has found that sulphite of ammonia acts energetically upon various organic substances containing (NO_4), as for example nitro-benzoic, nitranisic and nitro-salicylic acids. By the action of a concentrated solution of the sulphite upon an alcoholic solution of nitro-naphthaline two new isomeric acids are obtained in combination with ammonia. These the author terms naphthionic and thionaphthamic acids; supposed anhydrous they are represented by the formula, $C_{20}H_8NS_2O_5$.

Naphthionic acid is white, nearly insoluble in cold water and alcohol, more soluble in boiling water from which it crystallizes by cooling in acicular crystals of a satiny lustre. The naphthionates are all soluble and crystallize easily. Thionaphthamic acid cannot be obtained in a free state but forms perfectly definite salts; those of potash, soda and ammonia are soluble and crystallize. When we attempt to isolate the acid it is resolved into sulphuric acid and naphthalidin $C_{20}H_9N$, which last may be obtained easily and in abundance by distilling a thionaphthamate. The author has found that naphthalidin is converted by perchlorid of iron, and by oxydizing agents into *naphthaméine*, a new substance of a fine blue color, the formula of which is not given. —*Comptes Rendus*, xxxi, 489, 30*th Sept.*, 1850.

[*Note.*—The naphthionic and thionaphthamic acids of Piria may be regarded as "*amic acids*" analogous to aminsulphuric acid, SO_3, $HO+SO_2NH_2$ or $S_2O_5NH_2+HO$, oxamic acid, &c. Piria's acids on this view would be represented by the formula, SO_3HO+SO_2, $N\,C_{20}H_8$; if naphthalidin be considered as ammonia in which one eq. of hydrogen is replaced by one eq. of $C_{20}H_7$, the body $N\,C_{20}H_8$

may be regarded as NH_2 in which the same substitution has occurred. The isomerism of the two acids may be due to the existence of two isomeric radicals $C_{20}H_7$.]

11. *On Nitro-hippuric acid.*—BERTAGNINI has found that nitro-benzoic acid taken into the stomach passes into the urine in the form of nitro-hippuric acid, $C_{18}H_8N_2O_{10}$, which has not hitherto been described. The author obtained the same substance however by acting on hippuric acid with a mixture of fuming nitric and sulphuric acids, and found that when heated with chlorohydric acid it was resolved into glycocoll and nitro-benzoic acids.—*Comptes Rendus*, xxxi, 470, *Sept. 30th.*

12. *Action of cyanhydric acid upon aldehyde ammonia.*—STRECKER has studied the action of cyanhydric acid upon aldehyde ammonia. When an aqueous solution of cyanhydric acid and aldehyde ammonia is evaporated upon a water bath, a brownish colored thick syrup remains, which after a few hours solidifies to a mass of fine needles. The new substance possesses basic properties but has not been farther studied. When two parts by weight of aldehyde ammonia and one part by weight of anhydrous prussic acid are mixed in solution, chlorohydric acid added in excess and the whole distilled, a liquid is obtained free from aldehyde ammonia but containing chlorohydric acid and a small quantity of prussic and formic acids. The liquid in the retort gives by evaporation and crystallization, sal-ammoniac and a mother-liquor containing a new substance, alanin. Alanin crystallizes from a warm solution on cooling in colorless, usually acicular, prisms, often of considerable size; the crystals are hard and crack between the teeth; they are soluble in water, slightly soluble in alcohol, insoluble in ether; the aqueous solution has a sweet taste, does not change vegetable colors, and gives no precipitate with the ordinary reagents. Above 200° alanin sublimes and condenses in fine snowy crystals; its constitution is represented by the formula $C_6H_7NO_4$, and it is consequently a homologue of glycocoll; the following equation represents its formation

$$C_4H_4O_2+C_2NH+2HO=C_6H_7NO_4.$$

Strecker observes that alanin has the same formula as urthethan, lactamid and sarkosin, from which however its chemical and physical properties sufficiently distinguish it; it combines with acids to form crystalline compounds, as well as with the oxyds of silver, copper, lead, and barium; in these respects therefore it resembles glycocoll. Heated with caustic potash, alanin yields ammonia and hydrogen, the residue distilled with sulphuric acid gives acetic acid. With peroxyd of lead alanin gives carbonic acid, aldehyde, and ammonia; when a current of nitrous acid (NO_3) is passed into an aqueous solution of alanin, nitrogen is evolved and *lactic acid* remains in the same modification with that which is obtained from sugar. The following equation,

$$C_6H_7NO_4+NO_3=C_6H_6O_6+2N+HO,$$

represents the reaction.—*Annalen der Chemie und Pharmacie*, lxxv, 1, *July*, 1850. WOLCOTT GIBBS.

13. *On the Nitroprussids, a new class of Salts;* by Dr. LYON PLAYFAIR, (Phil. Trans. for 1849, part 2d; L., E. and D. Phil. Mag., March, April, and May, 1850.)—Hitherto but little has been known in regard to the action of nitric acid upon the ferrocyanid of potassium. The most remarkable observation on the product of this reaction was that when added to a solution of alkaline sulphid, a magnificent purple color was produced.

Dr. Playfair in making a new investigation of this reaction, found that nitric oxyd was only given off when the decomposition was violent, while under more favorable circumstances it disappeared, leading to the belief that it exercised an important influence in the transformation. This was confirmed by further experiment. Nitric oxyd was absorbed by cyanid of potassium, which after the addition of protosulphate of iron, produced the characteristic purple color with alkaline sulphids. Ferrocyanid of potassium produced the same result, provided enough acid to take up the alkali had been previously added, and the mixture heated. Pure hydro-ferrocyanic acid by similar treatment furnished the acid of the new class of salts to which the name of *nitroprussids* is given.

These observations are valuable as giving an idea of the nature of the new salts, for the economical production of which, the following process is recommended. Common nitric acid is diluted with its bulk of water, and the quantity required to neutralize 53·3 grs. carb. soda (1 equiv.) is ascertained. Five such portions are to be used for every equiv. or 422 grs. of ferrocyanid of potassium—the whole of the acid being poured at once upon the powdered salt, which gradually dissolves into a coffee-colored liquid with the evolution of cyanogen, hydrocyanic acids, together with some nitrogen and carbonic acid. When the solution is complete, the whole is digested in the water-bath until the precipitate with sulph. iron is dark-green or slate colored. The solution is now allowed to cool—nitrate of potash crystallizes together with a white substance which proves to be *oxamid*. To form nitroprussid of sodium, which is more readily procured than the salt of potassium, the solution is neutralized with carb. soda, boiled and filtered from the dark-green or sometimes brown precipitate which forms. Concentration produces more of the latter substance; after another filtration the nitrates are allowed to crystallize. The liquid is now evaporated on the sand bath, and the nitroprussid of sodium removed as fast as it forms, the nitrates remaining being more soluble in the hot liquid. The salt may be obtained pure by crystallization from a hot solution.

Nitroprussid of sodium forms ruby-red prisms not unlike those of red prussiate of potash; it is not deliquescent, although soluble in two and a half pints of water at 60°, and still more readily in hot water.

The chief characteristic of the salts is the above named reaction with soluble sulphids. The author proposes this as the most delicate test known for that class of compounds. The beautiful purple color is however very fugitive.

The precipitates formed by the nitroprussids are salmon-colored in the protosalts of iron, light green with salts of copper, and not very striking with several other metals. With persalts of iron, salts of tin and mercury, and neutral salts of lead, no change is produced.

The nitroprussids are very liable to change, and hence the determination of their true formula is a matter of some difficulty. The industrious and accurate author records over one hundred analyses of the salts on the products of their decomposition. The analyses most trust worthy agree very nearly in assigning a composition which aside from its apparent complexity, seemed so improbable, that they have been repeated under every variety of circumstance with the view of obtaining simple results, which have however obstinately refused to show themselves.

The formula thus obtained is $Fe_5C_{24}N_{15}O_3R_5$. The author would have preferred the ratio Fe_5 to C_{25}, but, as we have said, the analyses would not allow of it. Various conjectures are given as to the rationale of this curious composition, upon which point another paper is promised.

We are indebted to Gerhardt for a series of formulas by which under his genus of Polycyanid, we can include without difficulty all the various compounds which have caused so much trouble to chemists, and to explain which at least two hypothetical radicals are generally required. Let $Fe\beta$ stand for iron with two-thirds its usual equiv., as in peroxyd, perchlorid, &c., and we have the following formulas:

Ferrocyanid,	$C_{12}(Fe_2R_4)N_6$
Prussian blue,	$C_{12}(Fe_2Fe\beta_4)N_6$
Ferridcyanid,	$C_{12}(Fe\beta_3R_3)N_6$
Turnbull's blue,	$C_{12}(Fe\beta_3Fe_3)N_6$

By similar experiments we can denote the composition of Everitt's salt, the complex ferrocyanids and the other varieties of Prussian blue. By doubling the equiv. to avoid fractions, we have the nitroprussids as follows:

Nitroprussids, $C_{24}(Fe\,Fe\beta_6R_5)N_{12}+3NO.$

Fe and $Fe\beta_6$ or $Fe\frac{1}{3}^2$ being together equal to Fe_5, as given in the analysis. The only difficulty is in the relation of 3NO. This from its somewhat basic character may be superadded to the polycyanids as NH_3 is to the ordinary cyanids. Possibly there may be some connection between this and the absorbtion of NO_2 by protosalts of iron. At any rate the formula expresses a relation to known compounds, and accounts remarkably well for some phenomena in the decomposition of the nitroprussids. G. C. SCHAEFFER.

14. *On a new property of Carbonic Oxyd;* by F. LEBLANC, (Comptes Rendus, April, 1850.)—In absorbing oxygen from a gaseous mixture by the ammoniacal subchlorid of copper, it was noticed that a large quantity of carbonic oxyd was also dissolved. The same reagent when protected from the action of the air was found to absorb the gas readily and still retain its property of becoming blue on exposure to the air or oxygen. G. C. S.

The solution of subchlorid of copper in muriatic acid possesses the same properties, absorbing the gas as readily as solution of caustic potash absorbs carbonic acid. It is remarkable that after saturation the subchlorid is not precipitated by dilution with water.

All attempts to procure a solid compound of the gas and salt failed. The quantity taken up was one equivalent of CO for one equivalent Cu. Cyanogen produces in the same solution a chrome yellow precipitate, which changes on exposure to the air. G. C. S.

15. *On the Aërometric Balance, an instrument for measuring the Density of the air in which it is placed;* by Prof. POTTER, (L., E.

and D. Phil. Mag., Aug., 1850.)—This instrument is proposed as a means for detecting local variations in the density of the air, dependent upon the particular proportions of its constituent gases or vapors. The principle of its construction is similar to that of the well known air-pump experiment, in which the equilibrium between a solid ball and hollow bulb is disturbed when placed under an exhausted receiver.

In the practical construction of the instrument a closed glass bulb is suspended from a hook carrying an agate plane, which rests on a knife edge at the short arm of a beam, the fulcrum of which is provided with a knife edge, &c., as in an ordinary balance, while the long arm terminates in a vernier, the angular deviation being measured on a graduated arc—forming in fact a species of bent-lever balance, the arms however being nearly in a line.

The instrument can be so adjusted as to become more delicate than a barometer reading to ·001 of an inch. A series of observations are given compared with the density as calculated from an aneroid barometer. The changes indicated by the two instruments are the same in direction but not proportional. G. C. S.

16. *Preservation of the Proto-Sulphate of Iron from Oxydation;* by M. Ruspini, (Journ. de Chim. Med., vol. v.)—The crystals are to be dried in blotting paper, and allowed to effloresce in a drying apparatus at 86° F. The salt may then be kept unchanged in bottles with glass stoppers.

We have seen the same result attained more readily by precipitation with alcohol. G. C. S.

17. *Freezing point of Water lowered by Pressure;* by Prof. W. Thomson, (L., E. and D. Phil. Mag., Aug., 1850.)—Mr. James Thomson the brother of the author has recently shown that the fundamental axiom of Carnot's theory of the motive power of heat, requires as a necessary consequence that the freezing point of water should be lowered by pressure. The result of his calculations gives ·0135 of a degree of Fah. as the depression in temperature for each atmosphere 29·922 inches.

The object of the author was to test the accuracy of these deductions. A suitable thermometer containing ether instead of mercury was inclosed in a glass case and hermetically sealed. Each division of the scale was equal to about $\frac{1}{7^{1}0}$ of a degree. The experiments were in Oersted's apparatus for the compression of water—the cylinder being filled with ice and water. The column of ether was found to descend immediately upon the application of pressure, and to rise as rapidly when the pressure was withdrawn.

Observation at 8·1 atmosphere gave a depression of 0·106° F.—at 16·8 atm. 0·232° F., differing by —0·003° F. and +0·005° F. from the theoretical depression.

It is worthy of remark that the observations were made without a knowledge of their coincidence with theory. G. C. S.

18. *Test for the Presence of Chloroform in the Human body;* by Dr. Snow, (Lond. Lancet in Chem. Gaz., June, 1850.)—The blood or other parts examined are heated by a chlorid of calcium bath, in a flask to which is attached a tube so bent that the condensed moisture may fall back into the flask, and that a portion of it may be made red-hot. This is connected with another tube terminating in a Woulfe's bottle, both moistened inside with a solution of nitrate of silver. The

chloroform is decomposed in passing the red-hot portion of the tube and the liberated chlorine or hydrochloric acid forms chlorid of silver, which may be tested by dividing the tube with a file, ammonia being tried in one half and nitric acid in the other.

The delicacy of this process may be inferred from the following facts. In undoubted cases of death caused by chloroform, the precipitate appeared as soon as the boiling point was reached. Portions of the muscles of the leg of a child amputated while under the influence of chloroform, gave the precipitate, a few minutes longer being required for its appearance. Two kittens were killed by the inhalation of less than one minim each, the presence of chloroform was detected on six successive days after death, no precautions having been taken to protect the bodies from the air.

It has been ascertained that, at the required temperature,—that of boiling water or a little higher,—no chlorids present in the human body can affect the test. G. C. S.

19. *On the behavior of Cuminic acid in the animal system;* by Dr. HOFMANN, (Journ. der Pharm., April, 1850.)—Benzoic and cinnamic acids having been transformed into hippuric acid, in their passage through the body, it seemed desirable to ascertain whether cuminic acid, a homologue of the benzoic, would undergo the same transformation.

Considerable quantities were taken over night by several persons. The urine on evaporation furnished nearly the whole of the cuminic acid unaltered, without a trace of hippuric acid. A repetition of the experiment gave the same result.

Toluylic acid, another homologue, did not reappear in the urine. A very minute quantity of an unknown crystalline neutral substance was obtained. G. C. S.

20. *Action of Essential Oil of Bitter Almond on the Animal System;* by C. G. MITSCHERLICH, (Buch. Report, iv; Chem. Gaz., Aug., 1850.)—The observations of the author in the main agree with those of Wöhler and Frerichs. The poisonous effects of the crude oil in small doses is due only to the prussic acid it contains.

The pure oil in small doses is oxydated and hippuric acid is found in the urine. In larger doses, one to two drachms, the oxydation is incomplete and the unaltered oil is found in the urine. In such doses it is less poisonous than oil of mustard but more so than the oils of juniper, savine, cinnamon, turpentine, lemons, &c. Its effect on the intestinal canal is similar to that of the above named oils.

When death is produced there is a rapid destruction of sensibility and of voluntary motion, while the accelerated respiration and pulsation still continue. G. C. S.

II. MINERALOGY AND GEOLOGY.

1. *Report of Progress, of the Geological Survey of Canada,* by D. E. LOGAN, Esq., *Provincial Geologist.* 116 pp. 8vo. *Toronto,* 1850.—During the past year, Mr. Logan has been occupied with investigations about Bay St. Paul and Murray Bay River, on the north side of the St. Lawrence, near longitude 70½° W., and also upon the south side east and west of the Chaudière.

The valley of Bay St. Paul, is the course of the river Gouffre, and Murray Bay River is a few miles to the west. Coal had been reported as occurring in this region, but incorrectly as it was proved, the rocks being the Trenton Limestone, calciferous sandrock, white quartz rock corresponding to the Potsdam Sandstone, and metamorphic rocks as gneiss, either granitic or syenitic. On the uplands, west of St. Urbian Church, the rock is hornblendic and contains large masses of titaniferous iron, one of which was 300 feet long by 90 broad. Among the fossils of the limestone are *Chætetes lycoperdon*, *Streptoplasma corniculum*, *S. crassa*, *Receptaculites neptuni*, *Schizocrinus nudosus*, *Leptæna alternata*, *L. sericea*, *Orthis pectinella*, *Atrypa ambigua*, *Platynotus trentonensis*, *Calymene senaria*, species described by Mr. Hall in his Report on the Trenton limestone fossils of New York.

There are also in the same valleys *tertiary* deposits containing marine shells, among which are *Tellina grœnlandica*, *T. calcarea*, *Saxicava rugosa*, and others; and they were traced to a height of 390 feet. At little Malbasic there were six terraces, and in other places, one or more were distinct and corresponded with terraces on the St. Lawrence.

South of the St. Lawrence the observations were of great interest, but we defer citing results till the survey is farther advanced.

On the *Gold of the Chaudière* region Mr. Logan gives some new information.—"The occurrence of gold in the gravel of the valley of the Touffe des Pins, a tributary of the Chaudière, has already been mentioned in a previous Report, and on revisiting the Signiory of Vaudreuil Beauce, a few days were spent in endeavoring to ascertain over what breadth across the stratification, the auriferous gravel might extend. Seven different places were tried, and the metal found in five of them; no attempt was made to determine in what quantity it existed, as without a greater expenditure both of time and money than the funds devoted to the Survey would permit, no such result as might have been considered a just criterion could possibly have been arrived at. We were satisfied to establish the fact of its presence merely, and the smallest particle of the metal was deemed sufficient for the purpose; two of the spots were indicated to us by Mr. Angers as localities in which he had himself met with traces; one of them was on a small brook, tributary to the Rivière à la Famine, entering it on the south side about four or five miles from its mouth. About a mile and a-half above the fall on the Famine, there commences an extensive deposit of clay, sand and gravel; we followed the section made through it by the river for about a mile and a-half, and constantly found the clay beneath and the gravel resting on it; towards the top of the gravel, the bank often presented a horizontal deposit of the mingled oxyds of iron and manganese, in some parts six to eight inches thick, filling the interstices among pebbles of various kinds, many of them being clay and talcose slate, quartz rock, chloritic sandstone, and some of them of white vitreous quartz with grains of black magnetic iron sand in the finer parts. The same deposit with the same arrangement exists on a small brook which gives a section through it at right angles to the main stream, on the S. E. side; ascending this about the third of a mile, and trying a few pounds of the gravel at the top which had not previously been moved, a small particle of the metal was immediately met with. Another locality was about a mile up the stream

which discharges into the Chaudière, opposite the Famine, on the Seignory of Aubert Gallion, being on the twenty-second lot of the domaine, where the metal was first observed by Mr. Fortier, one of the *censitaires*, in a narrow ravine with steep precipices of clay slate on each side; it occurs in the clefts of the slate constituting the bed of the stream, and in the clay and gravel immediately on the top of the rock, mingled with magnetic and chromic iron; the quantity of gravel at the spot is but small in consequence of the narrowness of the ravine, through which the water rushes with great violence during the freshets of spring; about a grain's weight of gold was here obtained; I have since been informed by Mr. Fortier, that he has traced it two miles farther up the stream. The metal was also met with close by the side of the river road, where it is crossed by the brook next below the previous stream. Mr. Hunt found traces of it in the gravel at the foot of the precipice of serpentine, just below the fall of the Guillaume River, where it was associated with grains of magnetic and chromic iron, as well as of rutile and ilmenite. He also discovered it about a mile below the Great Fall on the Bras, in similar gravel lying close on clay slate, where it could not be far removed from the band of serpentine constituting the rock of the fall.

These five localities, as well as that of the Touffe des Pins above mentioned, the Ruisseau Lessard, and the Ruisseau du Lac or du Moulin, in both of which particles have been met with, are all included in an area of about sixty or eighty square miles, with a breadth of about ten miles across the stratification, and I have been informed that traces of the metal have been found on the River Metgermet, flowing into the Rivière du Loup, about fifteen miles still farther to the south-east than the Rivière à la Famine."

The Report of Mr. T. S. Hunt, Chemist and Mineralogist to the Survey, is occupied principally with analyses of soils and mineral springs which may be noticed at length in another number.

2. *On the Gold Mines of Darien, Emigration to New Granada, and Canalization of the Isthmus of Darien;* by Dr. CULLEN, (Ath., No. 1189.)—(1.) The Isthmus is a territory of the Republic of New Granada; its most important part, and that which appears naturally best adapted for communication between the Atlantic and Pacific, lies between the Gulf of Darien and the Gulf of San Miguel. Numerous rivers flow into the Bay of Panama on one side, and into the Atlantic on the other; the principal stream is the river Santa Maria, forty miles long, and falling into the Gulf of San Miguel, unobstructed by sand-banks or bars. A few estates are still occupied by the Spanish, but most of the old towns and villages and forts have been long since deserted. About eight miles up the river Santa Maria (or Tuyra) is the village of Chapigana, with a corregidor and about 100 inhabitants, mostly Sambos and Negroes; Mr. Hossack, a Scot, and Don Pepe, a Portuguese, are settled here. A few miles above this village gold occurs abundantly, and about thirty miles above is the town of Yavisa, the capital of the territory and residence of the prefect Don Antonio Baraya. The population is scarcely 100, and the large fort is in good condition, but not garrisoned. The largest vessels can ascend nearly to the Chuquannaqua, a branch of the river Tuyra, a few miles below Yavisa, and up to which the tide extends. This country has been the scene of successful gold-mining

under the Spaniards, and of much buccaneering and futile attempts at colonization on the part of the British, from the days of Sir Francis Drake and Basil Ringrose (1680) to Macgregor (1819.) In the archives of the treasury of Panama is an account of former mining operations at the Mina Real, on the river Cana (a source of the Tuyra), in the Cerro del Espiritu Santo; the royal quinto or 5 per cent. on this mine averaged for a number of years three and a-half millions of dollars per annum, which would give seventy millions per annum for the whole produce; the mining was performed by negroes (never more than three or four hundred) who hewed out the rock, ground it in mortars by means of oxen, and washed it by a stream of water whilst grinding. The mines were closed in 1685 by command of the king of Spain, although in full operation at the time, on account of the numerous incursions of the buccaneers; they have never been re-opened, and the neighboring mountains, though rich in gold, have never been worked. Dr. Cullen found the soil on the banks of the streams very fertile, and himself collected 3lbs. of gold at various spots, and several pieces of quartz-rock with veins of gold in it. As an agricultural country, Darien presents the most favorable prospects; its fertile soil, and the rapid growth of the plantain sugar-cane which arrives at maturity in nine months, make it superior to Demerara, and, though abounding in rivers, it is free from swamps and land liable to inundation; the timber is equal to British Guiana, and game (including alligators and "tigers") is abundant.

(2.) The government of New Granada affords great advantages to immigrants in the form of employment, loans and grants of land; the average passage to Carthagena or S. Martha is thirty days, and emigrants can go out for £6 per head. The tracts to be colonized consist of high table-lands and elevated valleys (nearly 9,000 feet), with a temperate climate (50° to 80°) all the year. On the table-lands wheat will grow, and in the valleys coffee, cotton, cocoa, sugar-cane, and other tropical crops. The settler has his choice of climate, from the level of tropical vegetation to regions of perpetual snow; the country is scattered over with towns affording supplies, and means of internal and external communication. The population consists of old Creole Spaniards, and the religion is Roman Catholic, but perfect liberty is allowed; the government is a pure democracy. The population of the capital, Bogota, is 60,000. The Cordilleras form a great table-land or platform, on which are piled numerous mountains intersected by valleys in every direction.

(3.) In conclusion, the writer recommends the rivers Chuquanaqua and Savana as the most direct and feasible mode of communication with the Atlantic; the Savana is navigable by large vessels for ten miles, above which for fifteen miles it would require deepening, and then there remain only ten miles to the Atlantic, where the cutting would be assisted by a ravine. From a mountain on the river Lara, a branch of the Savana, both Atlantic and Pacific were visible. The canal would open near the old Scotch settlement of New Edinburgh at Punto Escoces.

3. *On the Glacial Phenomena of the Neighborhood of Edinburgh, with some Remarks on the General Subject;* by Mr. R. CHAMBERS, (Athenæum, No. 1189.)—The author compares the glacial phenomena of Scotland with those of Sweden, with this difference, that in Scotland much of the surface has been masked, and many of the glacial mask-

ings obliterated since the glacial epoch. The trap districts near Edinburgh often form long and narrow hills, running east-north-east, some of them 800 feet high, and several of them presenting cliffs to the west, and long gentle declivities on the east. Mr. Chambers described the Costorphine Hill as a stratum of trap dipping to the west, and with a cliff in a line north and south. In its crest, which rises to 470 feet above the sea, are three or four transverse clefts. On the west surface of the hill, the rock, wherever it is exposed, is found to be rounded (*moutonnée*), smoothed, and grooved. The grooves, and the clefts in the crest of the hill, all lie in one direction, viz., directed to a point to the north of east. There are also, to the east of the hill, long hollows, with rounded intervening swells; and these run in precisely the same direction. At various places between the hill and the sea are seen sandstone surfaces, worn down to a remarkable flatness and smoothness, and in several instances marked with striæ, all pointing in the same direction. In Edinburgh itself, the north side of the Castle rock is smoothed and horizontally grooved, as if by ice passing along the hollow below. In forming the Queen's drive, on the south side of Arthur's Seat, the surface of the rock in the hollow between that hill and "Sampson's Ribs," was found to be wholly smoothed, polished and furrowed and striated in the direction of the passage, which is easterly; on the north side of the same hill, the railway works have also laid bare a prominent mass of rock, polished and striated on its upper and western sides; other rounded and polished rocks occur up to a height of 400 feet. Throughout the Valley of the Forth, from the Pentlands on one side to the Fife hills on the other, from Linlithgow to Dunbar, the sandstone surfaces, wherever they come up, are likewise smoothed, and in many instances striated in an east-north-east direction. The trap hills rising in this valley are all long and narrow, generally free from abruptness on the sides, often abraded on the west, and generally sloping away gently to the east; the direction here also is always to E.N.E. Surfaces on the Pentlands and in Fife exhibit striation precisely conformable. In short, if a deep ice-flow passed through this valley, it might be expected to produce precisely the phenomena which have been observed. The similar markings in other districts of Scotland were shown for the most part, though not without striking exceptions, to be directed towards the east and south. Mr. Chambers adverted to the theory of debacles which was started to account for the appearances, as now nearly given up. Ice was generally acknowledged as concerned in producing them, because the appearances were precisely those which existing glaciers produce. But there was great room for speculation as to the circumstances under which the presumed glacial agent was applied. Mr. Chambers declined theorizing on the subject, but pointed out various conditions which any theory on the subject must explain. (1.) How ice could move over so large a portion of the North American continent, in a direction admitted to be tolerably uniform, allowing for slight deviations, easily explicable, as owing to inequalities in the original surface, and this without any mountain chain to give it forth. (2.) How this ice was capable of ascending slopes and topping mountains of considerable height. (3.) How, in such a valley as that of the Forth, there could be an ice-torrent of undeviating flow for many miles, and deep enough to envelope hills many hundred feet high.

4. *On Labradorite from the Island of Maui, Hawaiian Group;* by J. D. DANA.—The labradorite of Maui occurs within the large crater of Haleakala, and is in small glassy tabular crystals, nearly or quite transparent. The angle obtained between P and the cleavage plane was 86° 45′. There are no distinct lateral faces upon the crystals seen. According to an analysis by Mr. Adolph Schlieper,* the composition is

$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$
53·98	27·56	1·14	8·65	1·35	6·06	0·47=99·21
Oxygen 28·02	12·87	0·34	2·47	0·52	1·55	0·08

which corresponds to the formula of labradorite, and gives the special formula $(\frac{1}{3}\dot{C}a+\frac{1}{3}\dot{N}a)\,\ddot{S}i+\dot{A}l\,\ddot{S}i$. In a second incomplete analysis, Mr. Schlieper obtained

$\ddot{S}i$	$\dot{A}l, \dot{F}e$	$\dot{C}a$
53·88	28·40	8·87

This last result was obtained from specimens procured by the writer at the Hawaiian Islands, and it removes a doubt with regard to the locality of the other crystals, expressed in his Mineralogy, p. 686. This species is mentioned in the writer's Geological Report of the Pacific, &c., p. 230, where an imperfect analysis by Prof. Silliman, Jr. is given, made on less than a gramme of the mineral.

5. *Gibbsite.*—Prof. Silliman, Jr., has made a reëxamination of this mineral from Richmond Mass. for phosphoric acid by means of molybdate of ammonia, and has confirmed his former trial that it contains no phosphoric acid. This is true therefore of all the specimens he has examined, and must be generally true, if not universally, of all the specimens from that locality.

III. ZOOLOGY.

1. *On the order of Succession of Parts in Foraminiferæ;* by L. F. DE POURTALES.—(Proceedings of the American Association for the Advancement of Science, third meeting, held at Charleston, S. C., March, 1850, p. 89.)—Since the identity of the fundamental structure of animals and plants has been ascertained by Lehman, various attempts have been made to trace an analogy between the growth of the various types in the two kingdoms. These attempts have failed, in as far as the analogy has been found very loose, and the strong contrast which exists between them has been more fully brought out, rather than an agreement.

Mr. Pourtales has, for the first time, pointed out a direct, well-sustained analogy, which is to be found in the order of succession of the cells in foraminiferæ of the genera *Textularia*, *Candima*, *Biloculina*, *Triloculina* and *Quinqueloculina*. This succession agrees fully with the succession of leaves in plants—so fully that it can be expressed by the same fractions with which botanists are now in the habit of expressing phyllotaxis in the vegetable kingdom. This is, therefore, an important additional link in the investigation of the plan which regulates the normal position of parts in organized beings—a link which may lead to include in one universal formula the rhythmic movements

* See Dana's Mineralogy, p. 686.

which preside over the development of all finite beings, as the phyllotactic formulæ themselves are now known to express also the natural relations which exist in the movements of the bodies belonging to our solar system.

2. *On the Principles of Classification;* by L. AGASSIZ, (Ib.)—It may be said that investigations upon the structure of animals have already yielded all the information coming from this source which can serve to improve our classification of the animal kingdom.

After the great natural divisions of the animal kingdom have been circumscribed in accordance with their anatomical structure, after the classes of the animal kingdom have been characterized by organic differences, it is hardly possible to expect that further investigations upon the structure of animals will afford the means of establishing correctly the natural relations of the families. For it is already seen that the amount of organic difference which exists between the different families is either too insignificant to afford a test by which to settle their preëminence or inferiority, or so striking as to impress us with an *exaggerated* idea of their difference. Many examples could be quoted to show, that, in this respect, from the same identical facts, naturalists have arrived at very opposite conclusions. And this diversity of opinion among investigators of equal ability leads me to think that comparative anatomy has done its work in that direction, and that we must seek for another principle in order to settle in a natural way the respective positions of the minor divisions throughout the animal kingdom, and to set aside, once forever, the arbitrary decisions which we are constantly tempted to introduce into our classifications, whenever we attempt to arrange all the families in natural groups. Before so much had been done to improve the natural classification of the animal kingdom, it was hardly possible to notice how much was, on every occasion, settled by induction, and even arbitrary decision, beyond what the knowledge of facts would justify—for the brilliant results which the introduction of comparative anatomy, as the foundation of the classification of the animal kingdom, has brought to light, must naturally have blinded us to the imperfections and deficiencies which constantly accompany the most important improvements in the natural arrangement of every class. Nevertheless, our confidence in the possibility of ascertaining the natural relations of all animals has been increased by the growing agreement between the different systems; and there is no philosophical observer who has not noticed this process of gradual approximation towards a greater uniformity in the view taken by different observers of the natural affinities of animals, however concealed this agreement has often been in consequence of changes of name or transposition of the order in which the objects were introduced.

The time has, however, gone by when the mere translation of family names, or of more general or minor divisions, into another language, could be presented as a new system, and the raising of a secondary division into the rank of a primary group, or the lowering of a primary division into a subordinate position, constituted an improvement in the knowledge of the natural relations of animals. Nothing short of a material addition to the information we possess respecting any group of animals, can now be considered as a real advance in zoology.

It should be further considered that our object is not merely or chiefly to ascertain the structural relations of animals, but to know all the various relations which have been established between them, and which they sustain toward the world in which they live. The knowledge of the natural embryonic development—of the order of succession in geological times—of the geographical distribution upon the surface of our globe—and of the habits arising from their natural relations to the elements in which they live—all these considerations are of as great importance in our zoological studies as the knowledge of the structure and functions of their organs, to which, of late, more exclusive attention has been paid.

When comparing, in former years, the characters of fossil fishes, especially with a view of ascertaining their natural relations to the living types, I was struck with the fact that those of earlier ages presented many structural peculiarities, which occur only in the embryonic condition of the fishes of our days, and also that the older representatives of any family rank lower in comparison to their living representatives. This led me to infer that embryonic data might be applied with advantage to the correct appreciation of the natural relations of the various members of one and the same family, and perhaps also to the determination of the relative position of closely allied types.

Under this impression, I began to compare young animals of various families with the different types of the same family in their full grown condition, when I was forcibly struck with the close resemblance there is between the younger stages of development of such representatives as could otherwise be recognized as ranking high in their respective families, and the lower forms belonging to the same groups. This led naturally to the conclusion that the change which animals undergo during their growth might safely be taken as a standard to determine the natural order of succession of all the representatives of any given type within the limits in which the higher ones pass successively through transient forms which the lower ones naturally present permanently in their full grown condition.

This principle, once ascertained, led to the result, upon more extensive investigations, that a complete knowledge of the metamorphoses of animals, from the earliest period of their embryonic development to the last change they undergo before reaching their mature condition, would afford, throughout the animal kingdom, a true measure by which to ascertain precisely, and without arbitrary decision on our own part, the natural relative position of all the minor groups of the animal kingdom.

Beginning the revision of the animal kingdom with the type of the Articulata, it was not difficult, with these views, to ascertain that the Worms, as a natural type, rank lowest in this department, as they represent permanently a structural adaptation which is closely analogous to the earliest condition of development of the insects; that the Crustacea constitute a class intermediate between the worms and insects, and not superior to the insects, as some naturalists would have them; inasmuch as the highest combination of their rings presents us with an arrangement similar to that of the pupa of insects, in which the joints of the head and of the chest are combined in an immovable shield, as in the

pupa of insects, and in which the joints of the abdomen alone remain movable, is also the case among the highest Crustacea. The position of the insects as the highest class, can no longer be denied, when we consider that in them the body is at last divided into three distinct regions—head, chest and abdomen—and that the locomotive appendages, which, in the lower classes, are so numerous and uniform along the whole length of the body, are reduced to the region of the chest, and assume there a particular development.

Again, the transformation of the respiratory organs is an additional evidence in favor of such an arrangement, as will be admitted from the fact that Worms and Crustacea have chiefly a branchial respiration, while in insects it becomes aërial, at least in their perfect condition.

Once upon this track, it was easy to follow out the minor changes which these animals undergo during their final transformation, and to derive from the knowledge of these changes sufficient information to assign a definite position to all the subordinate groups in each of these classes. Taking the insects, for instance, into special consideration, we ascertain readily that chewing insects rank below the sucking tribes, as their larvæ are chewing worms, provided with powerful jaws, even in the case of those which, like Lepidoptera, have the most perfectly developed sucking apparatus in their mature condition.

Again, an investigation of the changes which the wings undergo in their formation, and the manner in which they are unfolded, when the perfect insect is hatched, led to the discovery that Coleopterous Insects, far from ranking high, must be considered as lowest among insects, inasmuch as the upper larval wings of Lepidoptera are a sort of elytra, which, after being cast in the last moulting, are succeeded by the more perfect membranous wing, which in its turn, undergoes such a development as to assign to those Lepidoptera, which have their wings folded backwards and enclosing the body, a position below those in which the wings spread sideways; and the highest position to those which raise their wings upwards. So that these investigations have settled even the relative position of the secondary minor groups in each of these orders, and though, as yet, imperfectly traced out, they have at least shown the principle upon which a natural classification of these animals might be carried into the most minute details, without ever leaving any point to arbitrary decision. Similar results have already been arrived at in other classes; as, for instance, among Medusæ, where naked-eyed Discophori, with alternate generations, must be considered as the lowest type, recalling, in one of their conditions, the appearance of the inferior class of polypi; when the covered-eyed Discophori, with their strobiloid generation, begins in its lowest state with a medusoid polyp.

Similar facts are known among Echinoderms, in which, among Crinoids, the highest free forms begin with germs provided with a stem, thus assigning, on embryological grounds, a lower position to all those which are provided with a stem.

In the same manner has it been possible to determine the position of Bryozoa among Mollusca below Ascidiæ, upon the ground that their embryonic development is similar. It has been possible, in the same way to assign to Pteropoda a position inferior to that of Gasteropoda proper, and not intermediate between Gasteropoda and Cephalopoda,

as anatomical investigations would seem to indicate. For it is now plain that the spreading appendages of the body of Pteropoda are not analogous to the long tentacles which encircle the head in cuttle-fishes, but correspond to the vibratory rudders of the embryo in marine Gasteropoda.

Again, the position of Foraminiferæ, seems to me no longer doubtful. They are neither microscopic Cephalopoda, nor Polypi, as of late it has been generally thought best to consider them, but constitute a truly embryonic type in the great division of Gasteropoda, exemplifying, in this natural division, in a permanent condition, the embryonic state of development of common Gasteropoda, during which the bulk of the yolk passes through the process of repeated divisions.

This principle—of embryological changes as a foundation of the natural classification in the internal arrangement of all the minor groups in the natural classes of the animal kingdom—applies with equal success to the Vertebrata.

We need only contrast the successive changes of tailless Batrachians during their metamorphoses, with the permanent forms of the caudate and branchiate types in that order, to be satisfied that the relative rank of all these genera can in no way be better determined, than by a direct comparison of the permanent forms of the whole group, with the successive changes in the embryonic condition of its higher types; and a comparison of the metamorphoses themselves, in the different genera, will leave no doubt as to which of them the highest rank should be assigned.

I have already, on other occasions, alluded to the improvements which are likely to be introduced into our classification of birds, upon considerations derived from embryological data. I may be permitted here to add, that even the classification of mammalia will receive decided improvements upon the consideration of their embryological changes. A single instance, even now, will at least show that the true relative rank of their families can be determined in that way. We need only compare, among true Carnivora, the Plantigrades, the Digitigrades, and the web-footed Seals, with the transformation of the limbs in the embryo of cats and dogs, to be satisfied that the order in which these animals are arranged by Cuvier, does not agree with their natural metamorphoses, and that the Plantigrades should rank below the Digitigrades, nearer to the Seals, and the Digitigrades highest; and the affinity of the Ice-Bear to the Seals will further sustain this statement.

These remarks will, at the same time, show that no investigations are at present more needed to improve our natural methods in classification, than a thorough study of young animals; and that an extensive illustration of the young of all the principal representatives of the great natural groups in the animal kingdom, would, for the present, contribute more to the advance of Zoology, than any amount of description of new species.

But these investigations of young animals should be made with a full knowledge of their various relations, and with the view of ascertaining chiefly those zoological peculiarities, which may illustrate more fully the value of all these relations.

There is another field of investigation hardly yet entered upon, which is likely to contribute largely to the improvement of our classification. I refer to the study of fossils, compared in their structural peculiarities with the embryos of their living representatives. It has already been shown that many fossils of the earliest geological periods have a close resemblance to embryonic forms of the present day; and that, in their respective families, these fossils rank among the lower types.

This result, in itself, should be a sufficient inducement to trace this double relation, and to ascertain from as many fossils as possible, whenever they are sufficiently well preserved to allow of such comparisons, what is the extent of their analogy to embryonic forms of the present period, and also what is the amount of affinity they have to the lower types of their respective classes.

I would mention, in this connection, the necessity of a revised comparison of the Trilobites, with the earliest stages of development of Crustacea, when it will be found, as I have already seen it, that almost all the genera of Trilobites seem to be the prophetic images, in a gigantic form, of the different types the Crustacea present in their embryonic state. The different degees of development of these different types, when contrasted with each other, will go far to assign to each genus, its appropriate rank. I venture even to say, that the time will come when the relative age of fossils, within certain limits, will be as satisfactory a guide in assigning them their normal position in a natural system, as the facts derived from the study of their structure,—so intimate are the connections existing between all parts of the wonderful plan displayed in creation.

Little or no advantage has as yet been derived from the study of the relations of animals with the elements in which they live, in ascertaining their natural relations among themselves; but even in this respect we may derive valuable hints from a careful study of the geographical distribution of all animals; and the mere nature of the elements in which they live naturally.

On reviewing lately the whole animal kingdom, with a view to ascertain what is the value of the natural connection between the animals and the media in which they live, with reference to organic gradation, I have satisfied myself that aquatic types are decidedly inferior to the terrestrial; the marine inferior to the lacustrine and fluviatile ones; that those which live upon the main land and burrow under ground are inferior to those which live above ground; that nocturnal types are inferior to diurnal types; and that under otherwise similar circumstances, representatives of one and the same group which differ in these respects, have a higher and lower rank, in accordance with their external circumstances; so much so, that where we have no other guide, an inference respecting their natural position may be fairly derived from their conditions of life.

It will thus be obvious that as soon as we introduce simultaneously into our classification considerations derived from all these different sources; as soon as we allow the embryonic development, geological succession, geographical distribution, and relation to the natural elements, to assist us in our efforts to assign to all animals a natural position in one great system, we shall be able to sketch a far more complete

picture of the great diversity which exists in nature, than if we allow ourselves to be guided chiefly by anatomical data; and my object at present is mainly to urge the necessity of studies in these different directions, with a view of improving our classification, and to insist upon the necessity of keeping in view, at the same time, all these facts, whenever we attempt to form a correct idea of the manifested relations which exist throughout the creation, as to all their different types, from the earliest period of the existence of animals up to the present day.

3. *Observations on the Blind Fish of the Mammoth Cave;* by L. Agassiz. (In reply to a letter of enquiry from the Senior Editor.)—The blind fish of the Mammoth Cave, was for the first time described in 1842, in the Zoology of New York, by Dr. Dekay, Part 3d, page 187, under the name of "Amblyopsis spelæus," and referred, with doubt, to the family of "Siluridæ," on account of a remote resemblance to my genus Cetopsis. Dr. J. Wyman has published a more minute description of it, with very interesting anatomical details, in vol. xlv, of the American Journal of Science and Arts, 1843, page 94.

In 1844, Dr. Tellkampf published a more extended description, with figures, in "Müller's Archiv," for 1844, and mentioned several other animals, found also in the cave, among which the most interesting is—a Crustacean, which he calls, "Astacus pellucidus," already mentioned, but not described by Mr. Thompson, President of the Natural History Society of Belfast. Both Thompson and Tellkampf speak of eyes, in this species; but they are mistaken. I have examined several specimens, and satisfied myself, that the peduncle of the eye only, exists, but there are no visible facets at its extremity, as in other crawfish.

Mr. Thompson mentions farther crickets, allied to "Phalangopsis longipes," of which Tellkampf says that it occurs throughout the cave. Of Spiders, Dr. Tellkampf, found two eyeless small, white species, which he calls "Phalangodes armata" and "Anthrobia monmouthia"—flies, of the genus "Anthomyia"—a minute shrimp, called by him "Triura cavernicola," and two blind beetles—"Anophthalmus Tellkampfii," of Erichson, and "Adelops hirtus;" of most of which Dr. Tellkampf has published a full description and figures, in a subsequent paper, inserted in Erichson's Archiv, 1844, page 318.

The infusoria observed in the cave resemble "Monas kolpoda," "Monas socialis" and "Bodo intestinalis"—a new Chilomonas, which he calls "Ch. emarginata," and a species, allied to "Kolpoda cucullus."

As already mentioned, Dekay has referred the blind fish, with doubt, to the family of Siluridæ. Dr. Tellkampf however establishes a distinct family which he calls "Heteropygii," for the single genus, "Amblyopsis." Dr. Storer, in his Synopsis of the fishes of North America, published in 1846, in the Memoirs of the American Academy of Arts and Sciences, is also of opinion that it should constitute a distinct family, to which he gives the new name of "Hypsæidæ," page 435. From the circumstance of its being viviparous, from the character of its scales, and from the form and structure of its head, I am inclined to consider this fish rather as an aberrant type of my family of Cyprinodonts.

You ask me to give my opinion, respecting the primitive state of the eyeless animals of the Mammoth Cave. This is one of the most im-

ago, proposed a plan for its investigation, which, if well conducted, would lead to as important results, as any series of investigations, which can be conceived, for it might settle, once for ever, the question, in what condition and where the animals now living on the earth, were first called into existence. But the investigation would involve such long and laborious researches, that I doubt whether it will ever be undertaken. It has occurred to me, that the final step would be a thorough anatomical study of the species found in the cave, with extensive comparison of allied species, found elsewhere—next, an investigation of the embryology of all of them, and when fully prepared by such researches, an attempt to raise embryos, of the species found in the cave, under various circumstances, different from those, in which they are naturally found at present.

If physical circumstances ever modified organized beings, it should be easily ascertained here. For my own part, however, I think that the blind animals of the cave would only show organs of vision during their embryonic state, in conformity with the normal development of the respective types to which they belong, and that even when placed under a moderate influence of light, incapable of injuring them, but sufficient to favor the growth of their eyes in the allied species provided with them, the young of those species peculiar to the cave would gradually grow blind, while the others would acquire perfect eyes; for I am convinced, from all I know of the geographical distribution of animals, that they were created under the circumstances in which they now live, within the limits over which they range, and with the structural peculiarities which characterize them, at the present day. But this is a mere inference, and whoever would settle the question by direct experiment, might be sure to earn the everlasting gratitude of men of science. And here is a great aim for the young American naturalist who would not shrink from the idea of devoting his life to the solution of one great question.

4. *On the Carcinological Collections of the United States;* by Prof. Lewis R. Gibbes, (Proc. Amer. Assoc., 3d meeting held at Charleston, S. C., March, 1850.)—This catalogue of the species of Crustacea in the principal collections in this country (exclusive of that of the Exploring Expedition at Washington) is enriched with many valuable notes, by the author, and descriptions of several new species. The names of the new species are as follows:—*Hayas aculeata*, from Key West, *Cryptopodia granulata*, from Charleston Harbor, *Carpilius lividus*, from the Sandwich Islands, *Carpilius prætermissus*, E. Indies, *Chlorodius Floridanus*, from Key West, *Panopæus Wurdemannii*, from Enterprise, Florida, *Lupa Sayi*, (Lupa pelagica of *Say*,) *Grapsus transversus*, from Key West, *Hepatus decorus*, Charleston Harbor, *Ilia armata*, *Porcellana ocellata*, coast of S. Carolina, *P. armata*, from Florida, *P. sexspinosa*, from Key West, *P. magnifica*, from Vera Cruz, *P. macrocheles*, coast of S. Carolina, *Ibacus novemdentatus*, *Callianassa grandimana*, from Key West, *Alpheus formosus*, from Key West, *Pontonia domestica*, coast of S. Carolina, *Hippolyte Wurdemanni*, from Key West, *H. paludosa*, fresh-water ponds, S. Carolina, *Squilla neglecta*, Charleston Harbor.

5. *Observations on the Fishes of Nova Scotia and Labrador;* by H. R. Storer, 24 pp. 8vo, (from the Bost. Jour. Nat. Hist., October, 1850.)—This valuable paper contains descriptions of the following species:—*Acanthocottus Labradoricus*, Girard, *A. patris*, H. R. Storer (figure 2 plate 7), *A. ocellatus*, H. R. Storer, *Gasterosteus Cuvieri*, Girard (figure 1 plate 7), *Gunnellus ingens*, H. R. Storer (figure 1 plate 8), *Salmo immaculatus*, H. R. Storer, *Platessa rostrata*, H. R. Storer (figure on plate 8.) There are also critical remarks and notices of many other species.

IV. Astronomy.

1. *The new Planet Parthenope.*—The small planet discovered by M. Gasparis of Naples, May 11, 1850, and denominated *Parthenope*, belongs to the group between Mars and Jupiter. The following elements of its orbit are furnished by Luther.

Epoch, 1850, May	25·0 m. t. Berlin.	
Mean longitude,	288° 40′ 43″·27	
Long. of perihelion,	316 49 51 ·82	m. Eqx. Jan. 0, 1850.
" " asc. node,	124 57 55 ·78	
Inclination,	4 36 56 ·75	
Angle of excentricity,	5 42 30 ·35	
Log. semi axis major,	0·3893138	
Mean daily motion,	924″·7747	
Sidereal period,	1401 days.	

2. *The new Planet Clio.*—Mr. Hind, of London, who discovered this planet September 13, 1850, first proposed to designate it by the name *Victoria*, but objections being made to this, he has consented to substitute the name *Clio*, which denomination will probably be adopted.

Several sets of the elements of the orbit of the new planet have been computed and published, from among which we select the one by Mr. Ferguson, of the Washington Observatory, given in No. 19 of Gould's Astronomical Journal. It is based on the observations of September 13, 21 and 30.

1850, Sept. 13, mean time Greenwich.	
Mean Longitude,	32° 48′ 29″·2
Long. of Asc. Node,	236 49 43
" " perihelion,	302 55 1 ·5
Inclination,	8 3 38 ·5
Angle of excentricity,	14 15 27 ·4
Log. semi axis major,	0·3729403
Mean daily motion,	978″·5796

3. *Another new Planet.*—M. Gasparis, at Naples in Italy, discovered, on the 2d of November, 1850, a new planet, resembling a star of the 9th or 10th magnitude. Its place Nov. 2, 7h. 3m. 6s·5 m. t. Naples, was R. A. 30° 31′ 49″·9 and N. decl. 7° 58′ 55″. The R. A. was diminishing, and the N. declination increasing.

4. *Petersen's Comet.*—On the 1st of May, 1850, Dr. Petersen, at the Altona Observatory, discovered a telescopic comet in the constellation *Draco*. D'Arrest has calculated the following elements, viz.

Time of perihelion passage,	1850, July, 23·48002	Berl. m. t.
Long. of perihelion,	273° 23′ 47″·84	M. eqx. 1850·0
" " asc. node,	92 53 23 ·30	
Inclination,	68 10 36 ·93	
Log. per. dist.	0·0339176	
Motion,	direct.	

5. *Bond's Comet.*—On the 29th of August, 1850, Mr. Geo. P. Bond, of the Cambridge Observatory, discovered a faint telescopic comet in the constellation *Camelopardus*. It was subsequently discovered by four independent observers. The following elements of its orbit by Mr. T. H. Safford, Jr., (Astr. Jour., No. 16,) are based on the Cambridge observations of Aug. 29, Sept. 3 and Sept. 8.

Time of perihelion passage,	1850, Oct. 19·3433	Gr. m. t.
Log. of perihelion distance,	9·751524	
Long. of perihelion,	89° 20′ 17″	
" " asc. node,	205 55 47	
Inclination,	40 10 52	

6. *Shooting Stars of August* 10, 1850.—Throughout the evening of Thursday, Aug. 8, 1850, the sky was quite hazy, and at dawn of the next day was found entirely overcast. The night of Friday, the 9th, was clear, and observations for the expected meteors were made by Messrs. J. L. Blodget, M. C. Weld and myself. During two hours and twenty minutes we noted *four hundred and fifty-one* different shooting stars as follows, viz.

	N. E.	S.	N. W.	
from 0h. 40m. to. 1 A.M.	15	28	12	= 55
" 1 2	40	107	69	= 216
" 2 3	43	78	59	= 180

Of these many were very brilliant, and the majority moved in paths which, traced back, would intersect in the vicinity of the constellation Perseus.

The night of Saturday, the 10th, was also clear. From 10h to 12h P. M., Messrs. Bradley, Blodget and Root observed *three hundred and twelve* different shooting stars, as follows, viz.

	N.	S.	W.		
10h.—11h.	48	80	45	=	173
11h.—12h.	55	36	48	=	139

From midnight to 3 A.M., Messrs. Wm. Hillhouse and H. W. Brinsmade observed *three hundred and fifty-one* different shooting stars, although many were lost by an intermission of about an hour on the part of one of the observers.

The foregoing facts show that the usual meteoric period of August was fully sustained the present year.

It may be worthy of mention that a slight display of the Aurora Borealis was seen here during most of the night of the 9th, and again on the night of the 10th.

E. C. Herrick.

7. *Meteoric Observations in November and December*, 1850.—For many years past the meteoric visitation of November 13th has failed, and the present year must probably be added to the number.

The morning of November 11th, 1850, was clear, and at 5 A.M. I watched for five minutes and saw only two meteors. The next morning was overcast. The morning of the 13th was nearly clear, and during a watch of about fifteen minutes I saw only three or four meteors.

In December, 1850, the evenings of the 5th, 6th and 7th were overcast and rainy. The sky became clear about 10 P.M. of the 7th, and two persons who were abroad between that time and midnight report that shooting stars were unusually frequent, but they made no definite observations. I watched a few minutes about 7 P.M. of the 8th, and again about 5 A. M. of the 9th, but saw nothing uncommon. E. C. H.

8. *Meteor seen in full Daylight.*—On Sunday, June 16th, 1850, a brilliant fire ball was seen in the northern sky, by two observers in New Haven, while the sun was shining in full strength, about an hour before its setting. The time was $6^h\ 25^m$; the sky clear.

The meteor was of a brilliant white, apparently as large as Venus, with a train about a degree long, and disappeared without apparent explosion. Its motion was slow, the time of flight being about two seconds. Mr. George Rice and Mr. J. P. Humaston, who were sitting together at the time, each saw the body independently. Their separate testimony gave its position as follows, viz., when first detected, N. 11° or 14° E., and altitude 27° or 35°; at disappearance, N. 14° or 11° W. and altitude 16°.

The meteor must have been of extraordinary brilliancy to have made itself visible in such circumstances, and had it occurred in the night season would, no doubt, have been a grand spectacle. If any person elsewhere saw the phenomenon, it is to be hoped they will publish their observations, in order to furnish the means for determining the magnitude, velocity and direction of the body. E. C. H.

9. *Meteor of September* 30, 1850.—On Monday evening, Sept. 30, 1850, about 8 o'clock, a meteoric fire ball of uncommon splendor was seen throughout New England and the adjoining regions. To an observer in Boston, it appeared to originate near the sword-handle of Perseus, and to move southerly descending to a point about three degrees below alpha Arietis, where it exploded, with a very brilliant flash.

An interesting account of this phenomenon has been published in the Daily Evening Traveller of Boston, Oct. 21, by W. C. Bond, Esq., Director of the Cambridge Observatory, accompanied by six figures, representing the phases assumed by the train remaining after the explosion of the meteor. From Mr. Bond's description we derive the following particulars.

"The meteor exploded leaving a bright train about eight degrees long, extending from near the *Head of Medusa* towards a point three degrees below the star *alpha Arietis*, this being the direction of motion, and projecting a portion of its mass forward about two degrees. This took place at $8^h\ 54^m$ m. s. t. of the Observatory, and in or very near the small constellation *Musca Borealis*, in R. A. $2^h\ 30^m$ and N. decl. 27°. There were numerous radiations, but nothing sparkling in its appearance. At $8^h\ 57^m$ this had subsided into a serpentine figure about half a degree broad in the widest part and ten degrees long. At 9^h

the preceding portion had extended upward, or, as expressed by one observer, 'it appeared to draw up its head like a serpent.' At $9^h\ 3^m$ the preceding portion had curved quite around.

"During these changes the meteor had continued a bright, conspicuous object, some ten degrees in length, lying nearly horizontal. It was examined with three different telescopes—the comet-seeker, the four-feet refractor, and the great Equatorial. The appearance was that of a congregation of minute bright clouds, of the formation usually denominated *cirrocumuli*."

At $9^h\ 7^m$ it had assumed a figure resembling the appearance of Halley's comet as seen by Sir John Herschel, at the Cape of Good Hope, January 28, 1836.

"The meteor now commenced a slow, regular motion, passing about a degree below the star *alpha Arietis*, towards a point somewhat above the planet Saturn, at the same time rotating apparently on a point answering to the nucleus of the explosion, and expanding in every direction."

At $9^h\ 28^m$ its external outline touched the planet Saturn. The body "was now extended in breadth to twelve degrees, its longest diameter reaching upwards nearly to the zenith. Its rotatory motion had therefore been equal to an angle of about ninety degrees in twenty minutes of time. Although it had now become a faint nebulous light, yet it continued to exhibit a well defined boundary until past ten o'clock, having been under observation *more than an hour*."

"From observations communicated by Hon. Wm. Mitchell, of Nantucket, combined with our own, we have ascertained that the vertical height of this meteor above the surface of the earth was about fifty miles, and its distance from Cambridge one hundred miles in a northeast direction."

We subjoin an account of the same phenomenon as seen by Mr. J. C. Hoadley.

"On leaving Springfield this evening, (Sept. 30th, 1850,) in the cars, at $8^h\ 51^m$, (Boston time) for Worcester, I opened the window for the purpose of casting a glance at Algol, when my attention was arrested by a bright ball of fire, of a bluish color, moving rapidly in a horizontal direction, from east to west, leaving a straight, clear line of yellowish light, and exploding with violet corruscations. My instantaneous impression was that it was a piece of artificial fire-works, like a flying pigeon, quite near, and perhaps twenty feet from the ground; but a moment's observation showed that it suffered no parallax from our rapid and increasing motion, and revealed it to be a meteor. It was then $8^h\ 53^m$, and the moment of extinction could not have been half a minute earlier.

The train of light seemed to remain equally distinct, straight and thread-like, for four minutes, and occupied the same apparent position in the heavens, viz.: from the Pleiades, westerly about twenty-five degrees, to the head of Cetus, parallel to the horizon, and elevated from it about twenty degrees, these angles being measured approximately with a pocket rule as a sector.

At $8^h\ 57^m$ the line of light began to curve upward near the west end, as though that part were wafted upward by a current of air; and at

$9^h\ 0^m$ the whole had moved towards the zenith relatively to the stars, about two degrees, still remaining straight from the east end to beyond the center, and thence convex upward to the west end, but growing broader and more diffusive. Its breadth at this time was about ten minutes, and its soft yellowish lustre fully equal to that of the planet Saturn shining near it in Pisces.

It continued to rise slowly, and to grow broader and more diffusive, until, at $9^h\ 18^m$ it could be just discerned as a faint light cloud in the lower part of Aries, about 8° above its first position, and occupying nearly the same place in azimuth.

During all this time we were in rapid motion, nearly in the direction of the meteor, and reached at $9^h\ 20^m$ the village of Palmer, sixteen miles from Springfield. No sound was heard at the explosion, or subsequently. A few other meteors were noticed during the evening, but only in usual numbers, and of ordinary appearance.

The preceding observations were noted at the time, with a pencil, and the times corrected on reaching Worcester, to Boston time.

Worcester, Mass.

10. *Periodical Meteors of August*, 1848 *and* 1849; by C. B. Forshey, (communicated for this Journal.)—1848.—For several years past I have been inclined to believe that the display of meteors usually seen on the 9th and 10th of August, commenced much earlier in the month.

For the purpose of determining this question, I observed from about the 20th of July, 1848. On the evening of the 26th, I was first rewarded by the appearance of several meteors which followed the proper direction, and had the usual characteristics of the August display. Again on the 29th I observed about one hour, and saw six meteors whose paths traced backward, passed near above the head of Perseus.

Again on the night of the 2nd of August, two observers with a good view, saw only four meteors of this description, from 9 till 10 P. M. In one hour after, I saw four meteors, with a view of about one-twentieth of the heavens. During the whole evening only four meteors were seen, not conformable to the radiant in Perseus.

From my position I could not be very sure of the *point* of intersection of the paths in all those regarded as conformable from their general appearance; but two I am sure would pass between the sword cluster and the head of Perseus, both moving horizontally.

August 3rd.—With Dr. Riddell and son, I observed from $8\frac{1}{2}$ to $9\frac{1}{2}$ P. M., with a most perfect view of the whole heavens.

During this watch we saw eight conformable and sixteen non-conformable meteors. A majority of the former pursued paths near the milky way. I rose about 2 A. M. on the 4th and observed some minutes, without seeing any meteors.

August 4th.—From the same lookout and with the same aid, I saw only two conformable meteors, to thirteen *sporadic* meteors, in one hour's observation—$8\frac{1}{2}$ to $9\frac{1}{2}$ P. M. One of the meteors not conformable, was very magnificent, starting near Alioth in Ursa Major, and passing N. E., inclined some 60° to the horizon. It was much like a rocket in brilliancy, and pursued a halting course, as if obstructed and diverted by the atmosphere. No sound was heard after its explosion though it was expected.

August 5th.—Watched occasionally for meteors but saw only one conformable.

August 6th.—Made several observations during the evening and night, but without seeing a single meteor. It would seem that there is a cessation of the display.

August 7th.—On board a tow-boat, bound for the S. W. Pass, observed all the evening to 10½ P. M. and saw only one conformable, and three sporadic meteors.

August 8th.—At Pilotsville, S. W. Pass, with a perfectly clear sky and perfect horizon, I observed two hours, without any satisfactory evidence that the phenomenon is continuing.

August 9th.—This night is the true anniversary of the August meteors;—being bissextile, the date is one day earlier.

On board the steamship Crescent City, from the mouth of the Mississippi, I commenced observation as the twilight faded, and soon was rewarded by the appearance of several brilliant meteors. The moon was very bright, obscuring stars of the third magnitude. In 2½ hours observation on one-sixth of the heavens, I saw 16 meteors, conforming to the radiant in Perseus, and four irregulars.

Mr. Franklin Soule, editor of the New Orleans Mercury, aided me one hour, from 9 till 10 o'clock,—my own watch continuing till after 11 P. M.,—with intervals of clouds. Probably one-third of the visible meteors were obscured by clouds. This estimate would indicate about 144 meteors visible in the whole hemisphere in the 2½ hours' observation,—and in the absence of a moon, not less than 100 per hour.

August 10th.—At three o'clock A. M., I rose for observation as the moon went down. The pilot of the boat informed me that the rockets were shooting all the time I slept. It was obvious at once that the number was greater than when I retired. From this time till daylight, 1¾ hours, I saw fifty-two conformable, and three sporadic meteors. A great number were very small, so that four of every five would have been invisible while the moon shone.

My view was very limited,—not more than one-eighth of the heavens being visible. But this was in the direction of the radiant point. This number would indicate near 300 visible meteors per hour, in the whole hemisphere. About one in three had no train; and about one-third seemed but a train or streak, without a nucleus. And of the sixteen with nucleus and train, eight were 10° long and four were 20° or more.

No sounds were heard. Some blazed before expiring. One left a white train, which was fifteen seconds in fading away. The color was uniformly pale white, except a few blazing ones.

The *center of radiation* for the August meteors has remained unchanged, in eleven returns I have witnessed of this phenomenon. A circle of about 3° radius, described from a center midway between the sword cluster, and η Persei, and a little N. W. of the line joining them, would include all or nearly all the intersections of paths traced backward. I find it necessary to extend the area beyond my former limits of 4°, as several of the best marked meteors would otherwise be excluded. Several were seen to originate near the center of this area and move one, two or three degrees, and expire without leaving the circumference indicated. Two are recollected which moved in the

line of vision, so directly as to present a star growing in the first magnitude and dying in the same spot.

1849.—"On the night of August 3rd, 1849, I observed a meteor, which from its character and course of transit, I recognized as belonging to the annual display, having its maximum about the 10th of the month.

From the 3rd to the 10th nearly every evening was cloudy till a late hour; and incessant occupation prevented such observation as I could have desired. Mayor Blanchard and Dr. E. H. Barton reported to me, meteors which they saw on the 7th and 8th which evidently from description belonged to the display. They represented them as numerous and very brilliant, and coming from the northeast.

August 10th.—The clouds cleared away at 10½ P. M., and I commenced observation from a position which commanded a view of about one-tenth of the heavens.

This field of view was from the head of Perseus, to a point 15° below the zenith and laterally as far as one could see, one tree covering the S. E. portion of the field. From Perseus to the horizon, a heavy cloud obscured the stars.

In one hour and fifteen minutes I counted twenty-six conformable meteors, and five sporadic. The moon rose meantime, and rendered the stars of the fourth magnitude invisible for the last half hour.

This portion of the heavens which I watched exhibited twice as many meteors as a field 90° distant, and about an equal number with a field directly opposite or 180° distant.

There was no perceptible change in the point of divergence. Several of the meteors originated within the circle. Assuming that the center is midway between η Persei, and the sword cluster, a radius of 2½° would include all the intersections observed this year. This has not moved in eleven years.* The pale, white color of the trains, or phosphoric streaks across the sky, distinguish these from all other meteors.

August 11th.—This evening I observed from 9¼ to 10 P. M. with the largest possible field of observation, and no moon. I saw three regular and five irregular meteors, and Mrs. F. in half an hour saw two regular and three non-conformable meteors.

August 12th.—Observed from 9 to 10 P. M. with a good field and clear night, and saw no meteors of any kind."

For several subsequent nights I continued casual observation but without results, different from the last.

My observations for some years past have appeared in different papers and periodicals, those of 1847, in the Sidereal Messenger. Some of these publications suggest the earlier appearance of the display and these now offered seem to demonstrate a partial cessation about the 7th, thus dividing the phenomenon into two displays,—with however the same radiant point, and the same characteristic phenomena. If not before noticed, I invite the attention of observers from the 25th of July of each year.

Oleanda, Carrollton, La., Oct. 15, 1849.

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* See my observations from 1837 to 1840 inclusive, published in the Transactions of the American Philosophical Society.

V. Miscellaneous Intelligence.

1. *Translation of part of a letter from Mr. E. F. de Furuhjelm, one of the officers of a Scientific Expedition sent out by the Emperor of Russia to the Northern part of Finnland and Lapland, to Oscar M. Lieber;* dated Kurfamo Kappmark, 67° N. L., July 28, 1850. (Communicated for this Journal.)—"At the beginning of June, I left Helsingfors for Uleaborg, about eighty Swedish miles or six hundred and forty English. In the latter town I had to provide myself with a suitable outfit for Lapland—tents, provisions, a cook, &c. There remained yet two hundred English miles to Kuusamo Kirube. The distance took us six or seven days, though hitherto we had traveled at the rate of eight miles an hour. The stations where we could procure horses became fewer and fewer, and frequently I was obliged to wait one or two days for horses. At Kuusama church all roads were at an end, and thence I was obliged to travel either on the lakes and rivers or on foot. When I say I am now in Lapland, I am wrong, for in this parish no Laplanders have lived within the last hundred years. Finnish colonists have pressed them on farther North, somewhat as has been done with your Indians. They have here some little agriculture (rye), and a few settlements. From ten to twenty miles farther north, we have the true Laplanders, who roam about with their reindeer. The scenery here partakes, however, entirely of the Lapland features. Summer lasts only from ten to twelve weeks; and in December the day lasts from eleven till two o'clock, and even these three hours are not what we would call daylight, but rather a kind of twilight. A few miles farther on they do not see the sun at all for a whole month. The population here is very sparse; fishery and breeding of cattle furnish the only means of subsistence. Reindeers are much used: a rich peasant has from three to four hundred; the Laplanders several thousand. Very few are seen here in summer, for, as soon as the snow thaws in spring, they are driven into the forests. In autumn almost the whole population go out; a large space is fenced in, and after tedious driving, they collect the half wild reindeer, and each individual selects his own—they are all marked—and takes them home. The whole winter the reindeer keep round the bays and inlets, and feed themselves by scraping out the moss from under the snow, and the peasants consequently do not have to look out for their feeding. For the winter, some dozen or two are broken in for the harness, for there are few horses here, and higher up none. A reindeer sledge (in Lapplandish *pulka)* is shaped like a boat *(conat)*. Reins are not used as with horses, only a strap round the neck. The animal may be in quickest motion, but so soon as I pull the strap to the side, it stands still. In driving in the *pulka*, we make use of cloaks of reindeer hide, through a hole in which the head is thrust. * * * Almost the whole of June, I could see the sun all night from the hill tops, considerably above the horizon. Night was as light as day, and I could make the most careful drawings and minute examinations of minerals. In June and July, we had intense heat, accompanied by innumerable gnats and flies. The peasants guard themselves against these tormentors by covering their face and hands with tar; I had a mask of gauze.

"Our expedition is headed by an old officer who is appointed to conduct the whole. * * * I am the second in command, as officer of the scientific department, and have a good deal to do. I direct where the men are to wash for gold, make geological maps and sections of the country, conduct the test-diggings for veins of various metals, &c. Then comes a man who has to see to order and discipline among the hands, to furnish provisions and keep up the communication, besides acting as paymaster. Then two gold-washers (Quartermen) who have learnt their trade in the Ural. A carpenter and blacksmith, and then fifteen or sixteen hands to dig, in all about twenty to twenty-five individuals. * * * The expedition costs the government about thirty or forty dollars a day, and as yet has not paid a cent! Living is rather cheap in these regions; I might live conveniently for about five cents a day, but as it is, what with a cook, tea, wine, and other things more or less luxuries, it amounts to about fifteen.

"Search for gold is always made in small valleys watered by creeks. The auriferous soil rests on plutonic and metamorphic rocks, e. g. mica-slate, clay-slate, diorite, (very common,) and always with sulphuret of iron, frequently sulphuret of copper. The gold generally occurs two feet from the surface, and is usually found in sand and clay, fine and coarse, together with rolled masses of rock, and always containing magnetic iron-sand, locally termed *Schliech*. The gold occurs only in minute particles. Since the 14th of June, I have examined about sixty valleys, and in all found gold, but as I have said, scattered very sparingly and in small grains."

2. *Notice of a remarkable Spring or fountain in Hollis, now Phipsburg, Maine, about seven miles from Saco and Kennebunk;* (communicated by the Rev. J. COGSWELL, from New Brunswick, N. J., November, 27, 1849.)—To Prof. SILLIMAN:—The fountain of which several years ago you requested me to communicate to you an account is situated in a hollow near a pine plain, about sixty rods S. W. from the lower meeting house in the town above named.

By accurate measurement the basin is sixty feet long, twenty-five broad, and four and a half deep—and this depth of water is at all seasons nearly invariable. The bottom is a hard, smooth surface of white sand, through which the water, at five or six places, occasionally breaks forth with so much force that an observer looking through the clear water upon a smooth bottom, is disposed to start back. When boiling the water is white and turbid and resembles in its ebullition that of the slaking of lime. After continuing two or three minutes, it ceases and the place through which the boiling took place, becomes smooth and so hard that it is difficult to press into it with a sharp pointed pole. When the boiling ceases in one place it breaks through in another; and it hardly ever ceases to boil in all parts at once. In a very few minutes after the boiling ceases in any particular place, the water becomes clear. The spectator, while he is looking on, may see the water break through in five or six places in succession, often irregular. When the sand is taken from the spring it coheres very closely, and when trodden under foot it gives a sound like that of a sled passing in cold weather over the snow. The sand is used for plastering and for sharpening instruments. The water is at the common temperature, and has

no peculiar taste. It issues from the fountain in a considerable stream, and about six miles below it falls into Saco river.

Remark.—As Dr. Cogswell, who has often visited this fountain, makes no mention of gas, we must presume that the force is hydraulic, and that this is probably an intermitting or perhaps more properly a remitting fountain, similar although inferior in power to the thundering spring near Mobile in Alabama.

3. *Barometric Observations made during a journey from Albany, N. Y., to the summit of Mount Washington in New Hampshire;* by JOEL W. ANDREWS, Albany, N. Y., 1850, (communicated for this Journal.)—The barometer used in the following observations has a calibre of 0·29 inch, and a glass cistern and a zero point to adjust the level of the mercury for each observation.

The attached thermometer is let into the instrument and covered with glass.

Place of Observation.	Distance in miles.	Time.	Hour.	Barometer.	Thermometer.
Albany, No. 42 High st., 100 feet above tide-water in the Hudson River, weather fair and calm,		July 25	6 A. M.	29·944	74°
East Bennington, Vt., near state house,	28	" "	2 P. M.	29·386	80
South Shaftsbury, Vt., near post office,	5	" "	P. M.	29·294	75
Shaftsbury Centre, Vt., " " "	2	" "	6 P. M.	28·926	70
Arlington, Vt., " " "	7	" "	7 P. M.	29·406	64
Manchester, Vt., near stage house,	8	" "	9 P. M.	29·220	67
" " " " " weather fair,	"	July 26	6 A. M.	29·26	61
East Dorset, Vt, near post office, about three-quarters of a mile from the summit level of the Otter Cr., and the Battenkill,	6	" "	A. M.	29·40	62
North Dorset, Vt.,	4	" "	A. M.	29·442	62
Danby, Vt.,	4	" "	A. M.	29·48	64
Wallingford, Vt., near post office, fair,	9	" "	A. M.	29·576	65
East Rutland, Vt., Village,	9	" "	12 noon	29·51	70
" " " "	"	" "	5 P. M.	29·45	68
" " " Mussey's tavern, near the foot of the Green Mts., west side,	3	" "	7 P. M.	29·408	64
Sherburn, Vt., Rufus Richardson's tavern, east side of the Green Mts., near the Queechy R.,	9	" "	10 P. M.	29·90	58
Sherburn, Vt., Rufus Richardson's tavern, east side of the Green Mts., near the Queechy R.,	"	July 27	6 A. M.	28·916	60
Bridgwater Valley, Vt., near the Queechy R., weather fair,	11	" "	9 A. M.	29·284	68
Woodstock, Vt., near stage house,	6	" "	10½ A. M.	29·446	76
White River Junction, Vt., level of the Connecticut and White R., under the railroad bridge,	10	" "	P. M.	29·802	76
Bath, N. H., near stage house,	45	" "	6 P. M.	29·54	76
Littleton, N. H., near Cobleigh's hotel,	15	" "	9 P. M.	29·212	66
" " " " " weather fair,	"	July 28	7 A. M.	29·212	62
Carroll, N. H., Mr. White's, White Mtn. house, near Ammonoosuc R.,	20	" "	12 noon	28·456	74
Carroll, N. H., Mr. White's, White Mtn. house. Start for Mt. Washington,	"	July 30	7 A. M.	28·40	71
Flat Rock, crossing the Ammonoosuc R., weather cloudy, sky overcast all day.	3	" "	9½ A. M.	28·12	76
Foot of the Mountain, crossing the Ammonoosuc R., weather cloudy, sky overcast all day,	2	" "	10¾ A. M.	27·354	72
Fabyn's Camp, about half way up the mountain,	2	" "	11¾ A. M.	26·10	68
Summit of Mt. Washington, (6 feet below,) (Returning from Mt. Washington.)	2	" "	1¾ P. M.	23·944	64
Fabyn's Camp,	2	" "	3¾ P. M.	26·10	65
Foot of the mountain, crossing the Ammonoosuc River,	2	" "		27·354	72
Flat Rock, crossing the Ammonoosuc R.,	2	" "	5¾ P. M.	28·114	72
White Mountain house,	3	" "	7 P. M.	28·40	70

Second day to Mt. Washington by way of Mt. Pleasant, weather fair and calm all day.

Place of Observation.	Distance in miles.	Time.	Hour.	Barometer.	Thermometer.
White Mountain house,		July 31	8 A. M	28·486	80
Flat Rock, crossing the Ammonoosuc River,	3	" "	9¾ A. M.	28 21	78
Summit of Mt. Pleasant,	4	" "	12 noon	25·41	72
Summit of Mt. Washington, (6 feet below,)	2	" "	2 P. M.	24·032	68
(Returning by way of Fabyn's Camp.)					
Fabyn's Camp,	2	" "		26·18	72
Flat Rock, crossing the Ammonoosuc River,	4	" "	6½ P. M.	28·184	72
White Mountain house,	3	" "	8 P. M.	28·49	72

By the foregoing observations I have ascertained the height of Mt. Washington as follows:

From tide water at Albany to the White Mtn. house,	1622·3
From White Mtn. house to summit of Mt. Washington,	4868.3
Distance of the instrument below summit,	6·0
Height above tide water,	6496·6

By my observation on the first day, July 30th, I make the height 39 feet less.

4. *Makerstoun observations on the Aurora Borealis;* by J. Browne, Esq., (Proceedings of the Royal Society of Edinburgh, vol. ii, 1850, No. 39, p. 344.)—A table of 184 auroræ seen at Makerstoun in years 1843 to 1849 is given in pages lxxv—lxxviii of vol. xix, part 2 of the Edinburgh Transactions; from this table the following results have been obtained:

A very careful outlook for auroræ was kept up throughout the whole period but especially during the first five years; an outlook warned by magnetic disturbance in circumstances unfavorable to the visibility of the meteor, and assisted by a practical acquaintance with the faintest auroral indications. In several cases, the auroral appearances were very faint; these are entered in the table as "Traces," and, in others, there was doubt whether the appearance was truly auroral; these are indicated by "Trace?" It should be noted that, with the exception of the years 1844 and 1845, auroræ were seldom looked for after midnight.

Diurnal variation of frequency of the Aurora Borealis.—The following are the numbers of times when auroræ were seen, at each hour, from 5^h P.M. till 5^h A.M., for the whole period—referring to the printed tables for the numbers for each season.

Hour,	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.
No.,	5	19	45	57	91	75	50	37	27	15	11	3	2

The greatest number of auroræ were seen at 9h P.M.; this result is independent of the effects of twilight, since 9h P.M. is also the hour of maximum frequency for the winter months. This hour is nearly the hour of maximum disturbance for the magnetic declination and dip; as, however, the maximum disturbance of the total magnetic force and a maximum of the magnetic dip appear to occur about 5h P.M., this also may be an epoch of maximum frequency or intensity, though this can only be determined in higher latitudes. It should also be remarked, that, since the epoch of maximum disturbance varies with the season,

so, therefore, it is probable will that of the frequency of the aurora ; some traces of this may be deduced from the previous table. In the winter quarter, November—January, four-fifths of the times at which auroræ were seen were for the hours *before* 10h P. M., whereas in the spring quarter there were only three-fifths seen before 10h P. M.

Annual Variation of frequency of the Aurora Borealis.—The first line following contains the numbers of auroræ observed in each month during the six complete years 1843–8, and the second line gives the numbers of hours at which the auroræ were seen.

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	16	26	14	6	0	0	7	13	27	23	11
50	62	65	43	8	0	0	10	32	44	58	38

The greatest number of auroræ were observed in March for the first six months, and in October for the last six months of the year ; none were observed in June and July. When the six months of 1849 are included, the number for February is twenty-six, and for March twenty-eight. The law of visible frequency of the auroræ is the same as that deduced already for magnetic disturbance ; namely, maxima near the equinoxes, and minima near the solstices, the minimum at the summer solstice being the principal. As, however, the shortness of night during the summer months must diminish the number of visible auroræ, it is by no means certain from these numbers that a minimum occurs at the summer solstice ; the fact of the minimum at the winter solstice is involved in no such difficulty. If we could assume that the auroræ had the same diurnal law of frequency at all seasons of the year, the existence of the summer minimum could be satisfactorily determined, by comparing the numbers of times which auroræ were seen at the five hours, 10h P. M.–2h A. M., during which (even in the months of August and May) there is little twilight to extinguish auroræ. The numbers are as follow, for these five hours in each month of the years 1843–8:

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	24	38	31	8	0	0	9	14	16	18	12

From these it is evident that the numbers in May and August are certainly less than for April and September ; but it has been already mentioned as probable that the diurnal law of frequency varies with the season, of which, indeed, a proof is to be found in the great excess of the numbers above for the spring months, compared with those for the autumn months, showing the later epoch of the maximum frequency in the former. An examination, however, of the table for the disturbance of the magnetic declination (Table 18, vol. xix., part 2,) will show that, though the maximum disturbance occurs after midnight in the months of May, June, and July ; yet in August and the two following months it occurs about 10h P. M., so that there can be no doubt of the less number for August than for September and October, if there should be a doubt in the case of May compared with April. The difference, however, even in the latter case is too great to be explained by any slight shift of the epoch of maximum frequency in the two months. Upon the whole, it appears certain that a minimum of actual as well as of visible frequency occurs in summer ; a result quite in accordance with

that for the amount of magnetic disturbance, which accordance is sufficiently close to permit us to complete it, by assuming that the number of auroræ is a *principal* minimum in summer.

It has been stated in the volume for 1844, p. 401, that this result was long ago obtained by Mairan; this statement, made chiefly on the authority of Kæmtz and Hansteen, is not quite accurate. It is true that Mairan's numbers give a rough indication of the law, as will be seen below; but when it is remembered that his table includes all the observations (229) of which he could find a record for upwards of 1,000 years, it will be evident, that the conclusion that a greater number of auroræ occurred at both equinoxes than at the winter solstice would have been hasty; this conclusion, however, is *not* made by Mairan, and, though he has combined the numbers of auroræ in a great variety of ways, he has made no combination exhibiting this fact. It did not enter into the necessities of his theory (that auroræ are the product of the solar atmosphere) to show that a greater number of auroræ happened in the northern hemisphere at the vernal equinox than at the winter solstice; he shews, indeed, that the number for one equinox is, and, in accordance with his theory, ought to be greater than for the other. Some other philosopher has the merit of first pointing out this fact.

The following are the numbers of auroræ by Mairan (Traité Physique et Historique de l'Aurore Boreale par M. de Mairan, 1733, p. 199); by Kæmtz (Complete Course of Meteorology, translated by Walker, p. 458); and by Hansteen (Mem. de l'Acad. Roy. de Belgique, t. xx, p. 117.)

	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sum.
Mairan, .	21	27	22	12	1	5	7	9	34	50	26	15	229
Kæmtz, .	229	307	440	312	184	65	87	217	405	497	285	225	3253
Hansteen, .	29	31	47	34	2	0	0	17	35	33	34	23	285
J. A. Broun,	22	26	28	16	6	0	0	7	16	29	23	11	184
Sum of last three,	280	364	515	362	192	65	87	241	456	559	342	259	3722

Mairan's numbers are probably included by Kæmtz; a few of the auroræ, included in M. Hansteen's list, are identical with those in my own.

Variation of the frequency of the Aurora Borealis with the Moon's Age.—This investigation is evidently beset with considerable difficulty, since the moonlight existing nearly extinguishes the appearances of all the fainter class of auroræ, and it renders the faintest wholly invisible; the careful watch, however, which was kept for auroral appearances at Makerstoun, probably renders the table given in the Transactions better fitted for such a question than any previous series of observations.

It should be remarked, that the latitude of Makerstoun, or perhaps even a lower latitude, is better fitted for this investigation than much higher latitudes; at least this is the case as long as only frequency of visibility can be considered. The French *Commission du Nord*, during their stay in Lapland, found auroræ existing, or probably existing, almost every night. In such places variation of frequency there is none, and variation of intensity alone remains for investigation. It is obvious,

that till some better mode of measuring this intensity can be devised for these high latitudes, we are forced to perform this operation in a rude manner, by moving to lower latitudes, where the fainter auroræ become invisible, and where, therefore, frequency is a test of intensity beyond a certain limit.

Combining the numbers of auroræ observed at each day of the moon's age into six groups of five days, (the first group, four and a-half days,) we find the average number of auroræ for one day of the moon's age in each group as follows, from the six and a-half years' observations:

Moon's age,	28d—2d	3d—7d	8d—12d	13d—17d	18d—22d	23d—27d
Number,	5·8	5·2	3·6	5·0	10·2	6·6

Did auroræ *occur* indifferently at all ages of the moon, we should expect to *see* the greatest number at conjunction, and the least number at opposition; this, however, is not the case, the greatest number was seen about two days before the end of the third quarter, and the least number about two days after the first quarter, or the visible maximum and minimum occurred at times *equidistant* from the epoch of opposition.

The frequency of auroræ, therefore, is a function of the moon's age. In order to determine the actual law, we may consider the probable effect of moonlight in obliterating the auroral appearances; remarking, first, that 9h P.M. is the epoch of maximum frequency for the aurora, and that upwards of five-sixths are seen before midnight. When the moon is about three days old, in the months from September to March, it begins to set sufficiently late, and to have sufficient light to render the earlier of the faint auroræ invisible; about the end of the first quarter, it does not set till midnight, and thus shines throughout the period of the occurrence of five-sixths of the auroræ: afterwards it increases in brightness and the maximum effect in extinguishing faint auroræ is evidently attained at opposition, when the moon begins to rise late enough to allow the earlier auroræ to be visible; towards the end of the third quarter when the moon does not rise till midnight, it is also evident that the number of faint auroræ rendered invisible must be very small. From the beginning of the fourth quarter, therefore, till conjunction, the numbers *seen* will obey nearly the true law of frequency; and as the visible maximum occurred before the end of the third quarter, the true maximum must have occurred even nearer to opposition. On the whole, it appears very certain, that the hypothesis of an actual maximum of frequency at opposition, and minimum at conjunction, is satisfied by the previous numbers of auroræ seen under the conditions of the varying duration of moonlight for the hours of maximum frequency. This hypothesis is in unison with the law of magnetic disturbance, which is a maximum at opposition, and a minimum at conjunction.

4. *Relative level of the Red Sea and Mediterranean;* (L'Institut, No. 874.)—The following measurements are by the engineers attached to the Expedition to Egypt in 1799, and by Bourdaloue charged in 1847 with examining and levelling across the isthmus.

	Expedition.	Bourdaloue.
Low water at Tineh,	0m·00	0m·00
High water at Suez,	9 ·90	2 ·27
Low water on the Nile at Mekias,	5 ·29	13 ·27

Bourdaloue's results, so different from the others, were obtained with excellent instruments and seem to be every way worthy of confidence. His investigations extended from Cairo to the mouth of the Nile; from Cairo to lake Temsah, near the centre of the isthmus, by the valley of Ouadeé Toumilat, and thence in two lines, one to Tineh and the other to Suez, the former sixty and the other seventy-five kilometers in length. Bourdaloue made two verifications of his measurements, which agreed very nearly with his principal measurements.

5. *Fall of Dust at Olsterholz, near Detmold;* (Monatsber. Berlin Acad., April, 1850.)—This fall of dust accompanied snow, with the wind from the southwest, in February, 1850, and it covered the earth to a thickness of two-thirds of a line. Ehrenberg has detected in it fifty organic forms of which forty had been observed by him in similar circumstances, while ten species were for the first time observed in dust transported by the winds. None of the species were new.

6. *Tenacity of Metals*, (Comptes Rendus, Juillet 29, 1850; Phil. Mag., Oct., 1850.)—As the results of numerous experiments, M. Baudrimont has arrived at the following conclusions:—

1. That the tenacity of metals varies with their temperature.
2. That it generally decreases, though not without exception, as the temperature rises.
3. That with silver the tenacity diminishes more rapidly than the temperature.
4. That with copper, gold, platina and palladium, it decreases less rapidly than the temperature.
5. That iron presents a very peculiar and remarkable case: at 212° F. its tenacity is less than at 32°; but at 392° its tenacity is greater than at 32°.

7. *Note.*—The views on the relations of vegetable development and the alternations of generation in Radiata, brought forward in the last volume of this Journal, p. 34, have been since found by the writer to have been recently presented, but at an earlier date, by Dr. W. B. Carpenter.—J. D. D.

8. Obituary.—The following letter, here cited from the Proceedings of the Academy of Natural Sciences at Philadelphia, announces the death of Dr. William Gambel, a naturalist of extensive attainments in science, especially in Botany and Ornithology, and highly esteemed by all who knew him for his nobleness of heart and personal worth. The letter is dated Mountain House, Alta California, March 25, 1850, and is addressed to the editors of the N. American and U. S. Gazette of Philadelphia. Dr. Gambel died on the 13th of December of last year.

Messrs. Editors,—I trust you will pardon the liberty I take in offering to the citizens of Philadelphia, through your valuable paper, a tribute to the memory of an eminent and worthy Philadelphian, who has fallen in this wild and far-off country. I refer to the death of Dr. William Gambel, former Secretary of the Academy of Natural Sciences of your city, who left for California in the spring of 1849, taking the overland route, to collect specimens illustrating the natural history of the Far West, and to explore, to some extent, the prominent geological features of the country between the Rocky Mountains and the Great Sierra Nevada.

He went from Independence to the upper crossing of the Kansas with a small company of gentlemen from Georgia, Florida and Virginia. After which his company joined Indiana Company, No. 1, of which I had command, and with us he continued until we reached Fort Kearney, on the Great Platte. There he separated from us and joined a company commanded by Captain Boon, of Kentucky, which followed the trail opened by Captain Hudspeth's company, crossing the Sierra, near the head of Sacramento valley. The trials of this rugged route across fearful mountains and great deserts proved too much for the Doctor's constitution, and on reaching his destination in California, he was seized with typhoid fever, of which he died. He had collected during his journey a large number of rare and interesting specimens, by which he had added largely to the rich store of knowledge he had previously gained. His loss is as sad as it is premature, and he sleeps in peace beneath the towering pines which cluster on a sunny hill-side stretching up from the bright waters of the *Rio de las Plumas*. He has departed early, but not unhonored, and though the afflicting dispensation will fall heavily on those to whom he was endeared by ties of relationship or friendship, yet their consolation will be strong in the knowledge that he fell in the midst of his honorable pursuit of knowledge, and the earnest and zealous unfolding of his natural and acquired gifts. Philadelphia owes to his memory a lasting tribute of respect for his science, virtue, worth, talent, and energy. Yours, D. B. Woods.

VI. Bibliography.

1. *A Discourse on the Studies of the University of Cambridge;* by Adam Sedgwick, M.A., F.R.S., Woodwardian Professor and Fellow of Trinity College. 5th edition, with additions and a Preliminary Dissertation. ccccxlii, and 322 pages, 8vo. London: 1850. J. W. Parker.—This admirable discourse, by Prof. Sedgwick, occupies but 94 pages out of the 760 that constitute the volume. The additions in the way of Preface and Notes have rendered it a full Treatise on the important subject of which it treats. The learned author, appreciating the truths and spirit of religion as well as of science, ably sustains his views against the materialism and Pantheism of the day. The argument of the Vestiges of Creation is shown up in its true light, as weak in logic and false in facts notwithstanding the plausible air which pervades the work. After much spirited argument, alternately severe and playful, Prof. Sedgwick observes, page 285:

I can find, here and there, within *The Vestiges*, something almost to match Oken's Snail*—"the exalted symbol of mind slumbering deeply within itself—the prophesying goddess sitting on a tripod!" Both Au-

* "Circumspection and foresight appear to be the thoughts of the Bivalve Mollusca and Snails.

"Gazing upon a Snail, one believes that he finds the prophesying goddess sitting upon the tripod. What majesty in the creeping Snail, what reflection, what earnestness, what timidity and yet at the same time what firm confidence! Surely a Snail is an exalted symbol of mind slumbering deeply within itself."—*Oken's Physiophilosophy*, Transl. published by the Ray Society, p. 267.

thors have long sat, slumbered, and dreamed under the *arbor Dianæ*. The Edinburgh Reviewer exhorted our Author to quit his seat; and told him that if he remained there, he might be stricken on the head, and have his cerebral organs shamefully put out of tune, and made to jar against all rules of harmony. The goddess, though chaste, is very mischievous. No divinity of the sky so fickle, and of so many faces:—and her motions are so wandering and inconstant, that they have puzzled and confounded the wisest heads since the days of Newton. But under the *arbor Dianæ* our Author still is sitting; and there it was that he evolved, in solitude, some of the queerest visions of his fantastical philosophy. We may take a passing view of one or two of them.

"After Man, the Order of *Primates* takes in Monkeys, Lemurs, Bats, and Sloths; and this Order rests on the Dolphin family. In this family each cerebral hemisphere is made of three lobes, as in Men and Monkeys. "It might be rash," says the cautious Author (*Vestiges*, p. 341), "to found any thing upon ancient accounts of the Dolphin—its familiarity with man, and its helping him in shipwreck—although it is difficult to believe these stories to be altogether without some basis of fact." He must have been napping under Diana's tree, thus to cut short his tale. Why did he not tell us of a man who, while Periander was king of Corinth, came over from Sicily riding cheerily upon a Dolphin's back? There is better historical evidence for this fable than for some others, quite as strange, that are vouched for in the *Vestiges*. But he adds, even while broad awake, "there is no doubt that the Dolphin evinces a predilection for human society, and charms the mariner by the gambols which it performs beside his vessel"—especially (he should have added) while it is catching the flying fishes. But does not the Shark also show the strongest internal love of the human family, though our Author thinks it hardly deserving of a place among the Vertebrates?

"'He may not be held a very fanciful naturalist who would regard the Megatherium as eager to climb the tree which he could only shake, and thus producing a progeny fitted to do that which was the object of his wishes;—or the Rock-nose Whale, which loves to rest its head on rocks beside the beach, as wishful of that mode of life which was at length vouchsafed to a more highly developed descendant. Such too may be found to be the true principle of perfectibility in nature—a continual, though it may be an irregularly shewn tendency, to press on to better and better powers—and indefinite improvableness, which may work as seconds in the individual, or strike hours in the species,' (vide p. 346.) But why does our author thus venture to steal the mantle of Lamarck and the elder transformationists? He had no right to stick their feathers in his plume. They told us that the Elephant rose upon the earth with a short neck—that he gazed unhappily on foliage he could not reach, and so his face was lengthened—that it was afterwards more lengthened till his snout could reach the branches—that his nose became prehensile—that he tugged at the branches with it till it was pulled into a trunk—and that then this feature became as stable as that of any other

happy Mammal. But our Megatherium worked another way. She was too heavy in her hinder parts to climb; but nature had given her gigantic strength; so she shook the trees of the old forests and tore them down, and then fed on their branches. But she was weary of this work, and sometimes (as we know) broke her head in doing it. So she wished for some mechanism to spare her all this trouble. Nature heard her prayer, and she brought forth a litter of climbing Sloths; which now disport themselves joyfully in the tree-tops, and spend their lives among the dishes of their ready banquet! We have all heard of the 'vanity of human wishes,' and we have all read, in our younger days, the merry tale of the three wishes and the ladle. Wishing, after all, seems to be but a sorry business. But, says our Author, Creation is now 'a fact accomplished;' and we have no right 'to expect the origination of species to be conspicuously exemplified (after this fashion) in the present day,' (vide p. 80). We do indeed still hear of the marvelous effects of pregnant longings even in the human species: but they sink into the shade in comparison of the natural progeny of wishes in the days of the Megatherium or the Rock-nose Whale, and the perfectibility of nature which strikes hours in the species, are, after all, I fear, but the jarring sounds of a smitten organ—the cerebral blights of Diana's tree." And also, page 288:—

"But I beg the reader's pardon; I am only speaking of the Author's dreams; and in truth he is an honest dreamer. Many a time during past years (while the Chimpanzee was living) have I wished for some clew to guide me to his hiding-place, that I might have the comic happiness of drawing him from the shade of Diana's tree, and going with him to the Zoological Garden of London, there to witness the emotions of his filial love while he was gazing on the solemn visage of one in the very type of his immediate ancestors. 'Not for nothing would he have started' at that perfect image of 'anticipated humanity!'"

2. *Elements of Natural Philosophy;* by W. H. C. Bartlett, LL.D., Professor of Natural and Experimental Philosophy in the U. S. Military Academy at West Point. Section I, Mechanics. 632 pp. 8vo. New York: 1850. A. S. Barnes & Co.; Cincinnati, H. W. Derby & Co.—The author of this excellent and well illustrated work, states in his preface that this volume is the first of three in which he proposes "to offer to academies and colleges, a course of Natural Philosophy, including Astronomy." This volume treats of Mechanics, and is independent of those which may follow. It is printed in type of good size, and marginal notes direct to the subjects of the paragraphs.

3. *The Recent Progress of Astronomy, especially in the United States;* by Prof. Elias Loomis, N. Y. University. New York: Harper and Brothers, 1850. 12mo, pp. 257.—The nature and plan of this valuable work will be best understood by an enumeration of the titles of the different sections, which are these. *The discovery of the Planet Neptune; do. of several Asteroids; do. of an Eighth Satellite of Saturn; New Observations of the Satellites of Uranus; Great Comet of* 1843; *Faye's Comet of* 1843; *De Vico's Comet of* 1844; *Return of Biela's Comet in* 1846; *Miss Mitchell's Comet; Expected Return of the Comet of* 1264; *Determination of the Parallax of Fixed Stars;*

Observations of New and Variable Stars; Distribution of the Stars in space; Motion of the Sun and Fixed Stars; Resolution of remarkable Nebulæ; History of American Observatories; Astronomical Expedition to Chili; Astronomical Results of Public Surveys; Determination of Longitude by the Electric Telegraph; Astronomical Publications; Manufacture of Telescopes in the United States.

The design of the work is to exhibit in a popular form the most important astronomical discoveries of the last ten years. The author has executed the task with his usual thoroughness and accuracy, and the student is here furnished in a condensed and reliable form with a large amount of important information, to collect which from the original sources would cost him much time and labor.

One omission should be noticed. We do not find in this volume any allusion to Kirkwood's celebrated law connecting the rotations of the planets with their masses and distances from the sun. In a history of American Astronomy especially, this discovery is entitled to an honorable mention.

4. *New Elements of Geometry;* by SEBA SMITH. 200 pp. 8vo, New York, 1850: G. P. Putnam.—The author calls Euclid to account for asserting that "a line is length without breadth" and "a surface is length and breadth without thickness." These definitions he declares to be false—a verdict that will be pronounced upon Mr. Smith's work by those who are not convinced by his arguments, among which number we happen to fall.

5. *Practical Hand-book of Medical Chemistry;* by JOHN E. BOWMAN, Fellow of the Chemical Society, London, &c. 288 pp. 12mo. American edition. Philadelphia, 1850, Lea & Blanchard.—This volume treats in Part I, of the Urine in all its conditions healthy and morbid; in Part II, of Calculi and Concretions; in Part III, of the Blood; Part IV, of Milk, Mucus, Pus, Bone, etc.; Part V, of the detection of various Poisons in organic mixtures, &c. It brings together information of great importance to the medical student, with a fullness of detail and illustration that will render it practically useful. The forms and appearances of crystallizations of salts are well represented by figures, and also the microscopic character of such organic matters, healthy and unhealthy, as are treated of. Modes of analysis are described and the composition of the more important of the substances mentioned is given.

6. *Geological Report on the Lake Superior Copper Region, Michigan;* by CHARLES T. JACKSON, M.D. Executive Document, No. 1, 31st Congress, 1st session. 566 pp. 8vo. Washington, 1849.—This Report by Dr. Jackson has been slow in appearing, owing to delays in its publication. It is greatly to be regretted that the valuable documents of Congress are printed on paper so poor and in a style so far below all ordinary publications of the day. There is certainly no reason in the nature of things why our government should not be as well served by its printers as the publishing houses of New York or Boston. We observe also with regret many typographical errors in this Report, which could not have been overlooked if the proofs had been sent to the author, or were read by one acquainted with the subject.

Dr. Jackson was one of the earliest explorers in the Lake Superior Copper Region, and some of the mines were first laid open by him. In the course of his investigations he has brought to light much valuable information, among which are many curious and interesting facts relating to the association of native copper and silver with the minerals of the amygdaloid of the region. A large part of his results have appeared in this Journal in former volumes,* and the last volume contains a resumè of his observations made as a Report to the American Association at Cambridge in 1849. It is not necessary therefore to enter into a detailed review in this place. The Report commences with a historical account of the working of the copper mines in former periods, and then proceeds to descriptions of the region, its explorations and mineral productions. Several analyses are given of rocks and minerals.

The volume contains a large number of maps, geological and topographical, besides some views. There are also catalogues of geological, mineralogical and botanical specimens.

7. *The Daguerrian Journal, devoted to the Daguerrian and Photographic Art, also embracing the Sciences, Arts and Literature;* semimonthly in numbers of 32 pages, 8vo. New York City, S. D. Humphrey, Editor and Publisher.—The rapid progress of science in this age is well seen in the fact that an art unknown a dozen years since now demands a separate Journal for the publication of the new facts and improvements daily coming to light. In this short time, as the Daguerrian Journal states, the number of artists in this profession has increased in America to ten thousand; and we believe that the skill here exhibited is acknowledged to be even superior to that of the land of Daguerre. This Journal is practical as well as scientific in character, and includes also information and criticisms on subjects connected with other popular arts as well as Painting and Sculpture.

8. *A Practical Treatise on the Construction, Heating and Ventilation of Hot-houses, including Conservatories, Green-houses, Graperies, and other kinds of Horticultural structures, with practical directions for their management in regard to light, heat and air;* by Robert B. Leuchars, Garden architect. 366 pp. 18mo, illustrated with numerous engravings. Boston, 1851. J. P. Jewett & Co.—This work is full of sound sense and science, and comes from a man well versed in his favorite art from much experience among the most extensive gardens of England. It is well fitted to be a guide in the construction and arrangement of horticultural structures, being complete in its details and judicious in advice. The various kinds of arrangements hitherto proposed are discussed, and whatever errors they contain pointed out, with a full explanation of their principles on scientific and practical grounds. The work closes with a number of tables relating to the atmosphere, vapor, dew-point, and other matters having a bearing on practical horticulture.

9. *Art's Echo of Science, Inventions and Patents;* a monthly of 16 pp. 8vo, commenced Aug., 1850. Edited by J. L. Kingsley and

* Vol. xlix, p. 81, and 2nd ser., ii, 118; vii, 286; x, 65.

Abram Longbottom, Civil and Mechanical Engineers and Solicitors of American and European Patents. New York.—This new Periodical is devoted more especially to the various practical arts, which are treated in a popular manner.

10. *Journal of the Academy of Natural Sciences of Philadelphia*, 2nd ser., Vol. II. Part I. Contents:—

J. L. LeConte: An attempt to classify the Longicorn Coleoptera of the part of America north of Mexico. (Concluded from p. 340, vol. I.)

T. A. Conrad: Descriptions of one new Cretaceous and seven new Eocene Fossils, (with a plate.)

J. Leidy: Descriptions of some American Annelida Abranchia, (with a plate.)

J. Cassin: Descriptions of Owls, supposed to be new, (Syrnium virgatum, S. albogularis, and Nyctale Harrisii,) in the collection of the Academy, (with three colored plates.)

W. Gambel: Description of a new species of Mergulus (M. Cassinii) from the coast of California, (with a colored plate.)

D. D. Owen and B. F. Shumard: Descriptions of new Crinoidea, from the sub-carboniferous limestone of Iowa, (with a plate.)

J. Deane: Fossil Footprints of the Connecticut valley, (with two plates.)

J. K. Townsend: On the Giant wolf of North America—Lupus gigas.

11. *Annals of the Lyceum of Natural History of New York*, Vol. V, No. 1.—Contents:

J. Bell: Observations on the Limosa scolopacea of Say.

G. N. Lawrence: Observations on the preceding paper.

J. Bell: On Pipilo Oregonus, as distinguished from P. arcticus.

J. L. LeConte: Synopsis of the Coleoptera of the group Cleridæ inhabiting the United States.

G. N. Lawrence: On Mimus melanopterus, with a plate.

G. Francis: Chemical Experiments: illustrating the theory, practice and application of chemistry. 1 vol. 8vo, pp. 250, with numerous cuts. *Philadelphia*, 1850. Daniels & Smith.

T. Graham: Elements of Chemistry. 2d edit. 2 vols. *New York*, 1840. H. Baillière.

Prof. M'Coy: The British Palæozoic Fossils added by Prof. Sedgwick to the Woodwardian Museum; in royal 4to, with numerous plates. *London*, (in the press.)

Sir W. J. Hooker: The Victoria Reginæ; in large imperial folio. *London*, (nearly ready.)

J. Dalton Hooker: A second series of the Rhododendrons of Sikkim Himalaya; imperial folio, with colored plates. *London*, (nearly ready.)

Mrs. Hussey: A second series of Illustrations of British Mycology; royal 4to, with colored plates. *London*, (in the press.)

W. Thompson, Esq: The Birds of Ireland; the third and concluding volume. 8vo. (In the press.)

H. Sowerby: Popular Mineralogy; royal 16mo, with 20 colored plates. *London*.

Humboldt's Cosmos, third and last volume, translated from the German by Col. and Mrs. Sabine. Post. 8vo. *London*.

H. T. de la Beche: The Geological Observer. *London*, (in the course of preparation.)

Zoology of the Voyage of H. M. S. Samarang, complete in one royal 4to volume, containing 55 plates, mostly colored, containing Vertebrata by J. E. Gray, Fishes by J. Richardson, Mollusca by A. Adams and L. Reeve, with the Anatomy of the

Spirula by Prof. Owen, Crustacea by A. Adams and A. White. *London*, 1850, Reeve & Benham. In cloth 3*l.* 10*s.*

F. Dixon: The Geology and Fossils of the tertiary and cretaceous formations of Sussex; 408 pp., with 44 plates. *London*, 1850. 3*l.* 3*s.*

E. G. Wilson: Chemistry, forming one of the volumes of Chambers's Educational Course. *London* and *Edinburgh*, 1850.

Dr. J. Anderson: The Course of Creation, or the Sequence of Geological Phenomena. Post 8vo. *London*, 1850.

Liebig and Kopp's Annual Report on the Progress of Chemistry.—Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, Physik, Mineralogie und Geologie, unter Mitwirkung von H. Buff, E. Dieffenbach. C. Ettling, F. Knapp, H. Will, F. Zamminer, herausgegeben von Justus Liebig und Hermann Kopp. 2d Heft for 1849. *Giessen*, 1850.

Annuaire Magnétique et Météorologique du Corps des Ingénieurs des Mines ou Recueil d'Observations Météorologiques et Magnetiques faites dans l'étendue de l'empire de Russie et publiées par ordre de sa Majesté L'Empereur Nicolas I, sous les Auspices de M. Le Comte de Wrontchenko, Ministre des Finances et chef des ingénieurs des Mines, par A. T. Kupffer, Directeur de l'observatoire physique central. *Année*, 1846; Nos. 1, 2, 684 and 232 pp. 4to with plates. *St. Petersburg*, 1849.—The supplement in No 2, contains besides other matter a series of facts relating to Earthquakes in Northern Europe beginning with the earliest records, by Alexis Perrey, Professor at Dijon; it occupies 30 pages of the volume.

Iconographic Encyclopædia of Science, Literature and Art, by G. Henz, Part 14.—R. Garrigue. *New York City.*

C. Lyell: On Craters of Denudation, with observations on the structure and growth of Volcanic Cones; 28 pp. 8vo. From the Quarterly Journal of the Geological Society.

Cavendish Society: L. Gmelin's Hand-Book of Chemistry, translated from the German. Four volumes published. Gmelin's work is beyond doubt the most complete and best arranged work on chemistry that has appeared.

T. A. Conrad: Description of one new Cretaceous and seven new Eocene Fossils from Georgia; 3 pp. 4to, with a plate. From the Journal of the Academy of Natural Sciences of Philadelphia. 2d ser. vol ii, part I, pp. 39–41.

C. Tomlinson: A Cyclopædia of Useful Arts, Mechanical and Chemical, Manufactures, Mining and Engineering, illustrated with several hundred engravings—to be published in numbers. G. Virtue, 26 Ivy Lane, *London*, and 26 John street, *New York.*

J. Kinnersley Smythies: Essay on the Theory of Attraction. 28 pp., 4to. *London*, 1850.

S. Lovén: Bidrag till Kännedom om Utvecklingen af Mollusca acephala Lamellibranchiata, (Embryological Development of certain Mollusca,) from the Kongl. Vet. Akad. Handl. for the year, 1848. 110 pp., 8vo., with 7 plates of numerous figures, exhibiting with great beauty the different phases of the egg in the course of its development and the structure of the perfect animal.

R. de Visiani: Flora Dalmatica. Vol. iii, part 1, large 4to, iv and 190 pp. *Lipsiæ.*

J. Payer: Botanique Cryptogamique, ou Histoire des Familles Naturelles des Plantes Inférieures. 1 vol. 8vo., with 1105 figures representing the principal characters of the genera. *Paris.* 15 *fr.*

Girardin et Dubreuil: Cours Élémentaire d'Agriculture. 2 vols. in 18mo, with figures. *Paris.* 15 *fr.*

J. E. Cornay: Eléments de Morphologie Humaine, Genèse des formes, loi d'ordre universel, appréciation des lois, des théories, des faits, relatifs à la Genèse des organes. 350 pp. in large 18mo, with 12 plates. *Paris*, 1850. 4½ *fr.*

H. C. Kefferstein: Mineralogia polyglotta; xii and 248 pp. large 8vo. *Halle*, 1849. 1½ *dol.*

G. A. Kengott: Mineralogische Untersuchungen. 2d Heft, with 2 lithographs; iv and 58—156 pp. *Breslau.* ⅔ *dol.*

C. F. Naumann: Lehrbuch der Geognosie. 1 Bd. 3 abth. *Liepzig.* 1 vol. complete 6½ *dol.*

L. Pfeiffer: Descriptions and Figures of Cacteæ. 2d Bd. 6th part. Imperial 4to. 5 lithographs and 16 pages of text. *Cassel.* 1 *dol.* half colored; 3 *dol.* whole colored.

R. Remak: Untersuchungen über die Entwickelung der Wirbelthiere. 1st part large fol., 40 pp. and 3 plates. *Berlin.* 4 *dol.*

F. J. Ruprecht: Die Vegetation d. Rothen Meeres, &c. *St. Petersburgh*, 1849. ½ *dol.*

Th. Scheerer: Isomorphismus und polymerer Isomorphismus, (from the Handwörterbuch der reinen u. angewandten Chemie.) Large 8vo, vi and 64 pp. *Braunschweig*, 1850. ½ *dol.*

Dr. G. C. Wittstein: Vollstandiges etymologisch-chemisches Handwörterbuch, m. Berüchsicht. der Geschichte u. Literatur der Chemie. *Munich*, 1847, 1848, 1849.

Dr. F. Unger: Genera et species plantarum fossilium. xl and 638 pp., large 8vo. *Vindobonæ.* 4 *dol.*

J. R. Blum: Grundzüge der Mineralogie und Geognosie. 8vo, iv and 162 pp. *Stuttgart.*

Catalogus Coleopterorum Europæ. Large 8vo, 82 pp. *Bautzen*, 1849. ½ *dol.*

E. Fries: Summa Vegetabilium Scandinaviæ. Large 8vo, last part, 261 to 572 pp. *Holmiæ.* Complete 3½ *dol.*

Handwörterbuch der reinen u. angewandten chemie, by Liebig, Poggendorff and Wöhler. 8vo, 4th volume, 3d part, (22d part of the series,) pp. 305 to 448, 8vo. *Braunschweig.*

J. J. Heckel: Beiträge zur Kenntniss der fossilen Fische Oesterreichs. 1st part, fol. 44 pp., with an atlas of 15 plates in folio. 1848.

J. Hyrtl: Beiträge zur Morphologie der Urogenitale-organe der Fische. 21 pp. with 2 fol. plates. 1849.

J. G. A. Kinberg: Monographiæ zootomicæ. I, Tragulus Javanicus. Large 8vo, 102 pp. *Lundæ*, 1849. At *Leipsic*, 1 *dol.*

Naumannia: Archiv f. die Ornithologie, vorzungsweise Europa's. 2d part, 8vo, iii and 104 pp. *Stuttgart.*

H. R. Schinz: Monographien der Säugethiere, with plates; 23d and 24th parts, imperial 4to, 15 pp., and 12 colored plates. *Zurich.*

C. A. Steinheil: Beschreibung und Vergleichung der galvan. Teligraphen Deutschlands nach Besichtigung im April, 1849. 64 pp., large 4to. *Munich.*

A. Wagner: Die fossilen Ueberreste gavialartiger Saurier aus der Lias-Formation in der K. palæontolog. Sammlung zu München. 96 pp., large 4to, with 8 plates. *Munich.*

Proceedings of the Acad. Nat. Sci. Philadelphia, June, 1850.—p. 56, Descriptions of new Birds in the collections of the Academy; *J. Cassin.*—p. 59, A new Carpolite from Arkansas; *T. F. Moss.*

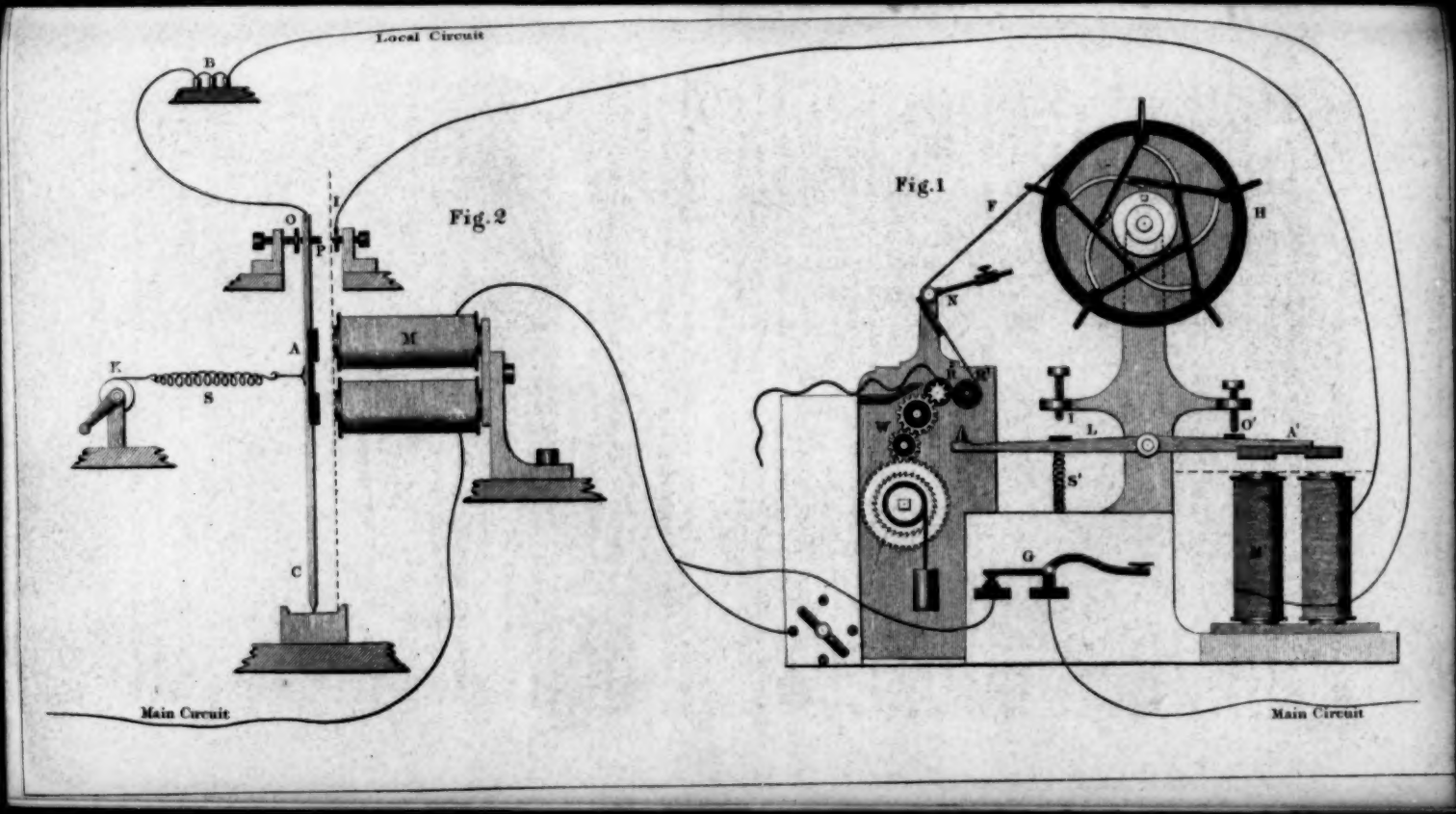
Proceedings of the Boston Soc. Nat. Hist., 1850.—p. 276, On a singular cavity in a quartz crystal; *F. Alger.*—Descriptions of shells of the U. S. Exploring Expedition, (genera Cardita, Cardium, Cypricardia, Arthemis, Venus, Arca); *A. A. Gould.*—p. 278, Analysis of Algerite.—p. 279, Description and analysis of an Asphatum from New Brunswick; *C. T. Jackson.*—Note on some fossils of the Mississippi alluvium at Memphis; *J. Wyman.*—p. 288, Microscopic appearance of Vermiculite after heating; *Dr. Burnett.*—On a peculiar appearance of Water; *Desor.*—p. 289, Explanation of a "shower of flesh and blood;" *J. Wynan.*—p. 290, Phosphorescence of a fire-fly from Cuba; *Dr. Burnett.*—p. 291, Terraces of Lake Erie; *Desor.*—p. 292, Shells of the Exp. Expd., (Genera Cyclas, Cyrena, Anodon, Unio;) *A. A. Gould.*—p. 296, On Vibrios; *Dr. Burnett.*—p. 297, Tellurium Ore of Virginia; *C. T. Jackson.*—p. 302, On the genus Cottus; *Girard.*

Transactions of the Royal Society of Edinburgh. Volumes xviii and xix, Makerstoun Magnetical and Meteorological Observations. Vol. xx, Part I, for the session of 1849–1850.—On the Volcanic Geology of the Vivarais; *J. D. Forbes.*—On a Process in the Differential Calculus and its application to the solution of certain Differential Equations; *Rev. P. Kelland.*—Constitution of Codeine and its Products of decomposition; *T. Anderson.*—On the Equilibrium of Elastic Solids; *J. C. Maxwell.*—On a Peruvian Musical Instrument, like the Syrinx of the Ancients; *T. S. Traill.*—On the mechanical action of Heat, especially on gases and vapors; *W. J. M Rankine.*

Annales des Sciences Naturelles, *Paris*, DECEMBER, 1849.—On the circulatory apparatus and organs of respiration in the Arachnidæ (continued); *E. Blanchard.*—

Note on the blood of the Arachnidæ; *E. Blanchard.*—On the genital "armure" of Insects; *L. Duthiers.*—Biographical notice of Blainville; *M. Edwards.*—Botanical Excursion across the French Ardennes (continued); *E. J. Remy.*—Essay on the Phytostatics of the Java and vicinity, or the distribution of vascular plants as dependent on the character of the subjacent rocks; *J. Thurmann.*—Plants from seeds recently received at different European gardens.—JANUARY, 1850.—On Annelida; *A. de Quatrefages.*—On the Naturalizing of the Alpaca in France; *E. Deville.*—Researches on Coral-zoophytes; *M. Edwards* and *J. Haime.*—On the "collet" in plants and on the nature of some tubercles; *Dr. Clos.*—Conspectus of genus Nitraria; *Jaubert* and *E. Spach.*—Monograph of the Melastomaceæ in the Paris Museum (continued); *C. Naudin.*—Additions to the Flora of South America; *H. A. Weddell.*—FEBRUARY.—On Coral Zoophytes, (continued); *M. Edwards* and *J. Haime.*—Experimental Researches on the Spermatozoids "des Hermelles et des Tarets," and on artificial fecundation of the Eggs; *A. de Quatrefages.*—Additions to the Flora of South America (continued); *H. A. Weddell.*—Note on the genus Uropedium; *A. Brongniart.*—Opthalmoblapton, genus of Euphorbiaceæ; *F. F. Allemão.*—New species of Spartina, from the shores of the Mediterranean; *E. Fabre.*—Melastomaceæ of the Paris Museum (continued); *C. Naudin.*

Archiv für Naturgeschichte, NO. III, 1848.—On the process of subdivision in the eggs of snails; *H. Rathke.*—Echinorrhynchus Tuba; *Dr. Creplin.*—New intestinal worm found in Python bivittatus; *A. Retzius.*—Anatomy and Natural History of the Angiostoma limacis; *F. Will.*—A small mammal from Syria and Africa; *A. Wagner.*—On the Gregarinæ; *A. v. Frantzius.*—Review of the works and memoirs on Insects, Arachnidæ and Crustacea, for 1847, (continued but not completed); *W. F. Erichson.*—Ibid for Mammalia; *A. Wagner.* NO. IV. 1848.—On the Gregarinæ; *A. v. Frantzius.*—Ornithology of Faroe; *A. Holm.*—Report on works and memoirs on Mammalia for 1847 (continued); *A. Wagner.*—Ibid for Systematic Botany; *A. Grisebach.*—NO. V, 1848.—Index for the first fourteen years of the Archiv.—Review of works and memoirs on Herpetology, Ichthyology and Mollusca for 1847; *F. H. Troschel.*—Ibid for Geographical and Systematic Botany; *A. Grisebach.*—NO. III, 1849.—On the Boring of Mollusca; *A. Hancock.*—On the development of the Targipes lacinulatus; *M. S. Schultze.*—On growth by subdivision of the Nais proboscidea; *M. S. Schultze.*—On the Salmons of Sweden; *Nilsson.*—On the development of the mollusca acephala; *S. L. Lovén.*—Chætopterus pergamentaceus of Cuvier; *R. Leuckart.*—On the skeleton of the orang-outang; *Mager.*—Review of works and memoirs on Mammalia for 1848; *A. Wagner.*—Ibid for Ornithology; *G. Hartlaub.*—NO. IV, 1849.—On the skeleton of the orang-otang; *Mayer.*—A new Anguillula, and on the development of the Gordius aquaticus; *Grube.*—Review of works and memoirs on Ornithology for 1848; *G. Hartlaub.*—Ibid on Herpetology, Ichthyology, and Mollusca; *F. H. Troschel.*—Ibid on Entomology; *Dr. Schaum.*


Local Circuit
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